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SCIENCE.

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XV.—NOTES ON THE METEOR OF FRIDAY THE 6TH APRIL, 1877. By PROFESSOR O'REILLY.

[Read, April 9, 1877.]

THIS Meteor, seen from many places in the South of Ireland, where it apparently exploded, was also visible from Dublin and other localities still further north. It must consequently have been of more than ordinary size and brilliancy, meriting therefore some notice as a matter of record.

Owing to the peculiar conditions under which such phenomena occur, the impressions and estimates of individual observers naturally differ considerably as regards the colour, the size, and the direction of movement of such a meteor.

The real conditions can therefore be merely approximated by comparing a large number of individual descriptions. In the case, however, of the meteor having been seen to explode at the instant of its apparent passage across some fixed point or line, there remains an element by which its position at the moment can, to a certain extent, be fixed. This advantage I had when observing the explosion, the globe of flame appearing just to touch, by its lower rim, the ridge of the houses on the opposite of the road, as I endeavour to show in the accompanying drawing. Knowing the point where I stood at the time, I have been able to fix the apparent angle of the luminous globe above the horizon, at 15°, using for that purpose a pocket sextant and a level, so as to get a horizontal plane of comparison.

The colour appeared as that of cupric chloride when burning, that is, *bluish green*.

The size of the globe seemed to me to equal that of the setting sun.

The *time* was very nearly three to four minutes past 9 o'clock, P. M., Dublin time.

The *direction* in which seen was about S.W.

The *inclination* of the line of movement appeared to be from west to east, at about 80° from the vertical.

Comparing these observations with others communicated to the Cork newspapers, which I annex, I find the following additional *data*, which agree very fairly, in some respects, with my observations:—

"THE FRIDAY NIGHT METEOR.

"TO THE EDITOR OF THE 'CORK EXAMINER.'

"DEAR SIR,—I suspect that all your readers have been discussing the splendid meteor which visited us last night. I think it would be worth while if several who observed it compared notes, so as that we may discover what its distance from us was, and, if possible, also its size. I happened to see it from first to last. I must add that I live in the eastern part of the county, exactly in the 8th degree of lon-

become more ruddy. About three minutes after its appearance I heard the explosion. As sound travels fourteen miles a minute, the meteor must have been forty-two miles from me when the first explosion occurred; that is, as I calculate, nearly over the Old Head of Kinsale, but rather south of it, and at a height then of thirty miles. While exploding it must have gone twelve miles farther, and its remains may have fallen among the fishing fleet. The meteor appeared to me to have a diameter about one-tenth the apparent diameter of the moon. Hence its real diameter must have been about 200 feet. I calculate its velocity to have been twenty-five miles a second.

"Hoping you may think my observations worth reading,

"I am yours,

"NO ASTRONOMER."

"THE PHENOMENA OF FRIDAY NIGHT.

"'CORK DAILY HERALD.'

"Our Tralee correspondent wrote on Friday night:—

"'A strange meteoric phenomenon was observed here to-night, at a few minutes past nine. Some persons assert that a ball passed along the heavens, and after a second or two it exploded. Immediately the most minute object was observable by the illumination produced. The light only lasted for a few seconds, and it is positively stated that, after the explosion of the ball, fragments of it fell outside the suburbs, and noise resembling thunder was heard after the explosion.'"

"Our Kinsale correspondent writes:—

"'Those "toilers of the deep" who were at sea fishing on Friday night had a good opportunity of observing the meteor. It resembled very closely the full moon, and carried a trail very much like that of a rocket. It shot through the heavens form north-east to south-west, in which point it disappeared. The brilliancy of the blue light which emanated from it, as it sped along the clear sky, made the smallest object on the earth quite visible, and in a few minutes after its disappearance a deep dull sound like distant thunder was heard in a south-westerly direction, which leaves no doubt that it was the noise which followed.'"

"A correspondent writes to us from Kilrush:—

"'An aerolite (*sic*) of remarkable brilliancy and size illuminated the town after nine o'clock last night, and burst noiselessly. It was for more than thirty seconds in view. It was observed by hundreds who were in the streets.'"

The writer, "No Astronomer," gives the size as about one-tenth the apparent diameter of the moon. Refraction would of course make it appear larger to a spectator situated at Dublin, who saw it at the comparatively low angle of 15°.

The height over Cork which he estimates for the globe, at the moment of the explosion, agrees with that resulting from the 15° altitude which I observed.

The direction of movement which he noted S. W. leads to the conclusion that the plane of movement had a westerly inclination.

The Kinsale correspondent gives the size of the meteor as *that of the full moon* (a sufficiently close approximation to mine); the colour

XVI.—REPORT ON THE HISTORY OF IRISH FOSSIL MAMMALS. By A. LEITH ADAMS, F. R. S., F. G. S., Professor of Zoology in the Royal College of Science for Ireland.

(ABRIDGMENT OF THE REPORT.)

[Read, June 10, 1877.]

THE following Abstract has been furnished at the request of the Committee of Publication of the Royal Irish Academy, in consequence of the original Report requiring more illustrations than were considered advisable to recommend, on account of the attendant expense.

The extinct and fossil mammals of Ireland have been variously enumerated. Several of the latest writers on the subject include domesticated oxen, sheep, and goats among the feral lost animals,[1] whilst certain mammals are enumerated whose existence appears doubtful when carefully compared with typical examples of the species to which they have been referred.

According to the views apprehended in this Paper, the only extinct mammals hitherto discovered in Ireland are as follows:—

Wild Horse (*Equus caballus*).
Wild Hog (*Sus scrofa*).
Irish Elk (*Cervus megaceros*).
Reindeer (*Cervus tarandus*).
Hairy Elephant (*Elephas primigenius*).
Grisly Bear (*Ursus fossilis, vel U. ferox fossilis*).
Wolf (*Canis lupus*).

Of recent Irish mammals, the only species hitherto found in fossil states are the Alpine Hare (*Lepus variabilis*), and the Fox (*Canis vulpes*), and Red Deer (*Cervus elaphus*).

The so-called fossil Cetacean remains reported to have been discovered in Ireland refer, as far as I can make out, to detached bones, none of which have been determined as belonging to extinct or fossil species.

Again, the asserted discoveries of exuviæ of certain quadrupeds in Irish strata, to wit, Hippopotamus, Ursus spelæus, Ursus maritimus, Ursus arctos, Cervus alces, appear to me to rest altogether on unsatisfactory evidence. On these accounts I conclude that my researches into their histories have not been a work of supererogation; for, although it is demonstrated thereby that the list of Irish fossil mammals is remarkably small as compared with England, and in several respects deficient as compared with Scotland, the objects, as far as they extend, belong to lost mammals, with one exception, also met with in the

superficial deposits of the latter country—a circumstance of some importance when the recent and extinct animals are considered in relation to physical geology and their probable route of migration to Ireland after the Glacial Period.

I shall now proceed to briefly indicate the data on which the foregoing determinations are based.

The Wild Horse (*Equus caballus*).

Remains of a small Horse, including many bones, but no teeth, were found in Shandon cave in connexion with the Mammoth, Reindeer, Red Deer, Wolf, Cave Bear (*U. fossilis*, Goldf.), Fox and Hare.[2] Mr. Thompson also refers to teeth from gravel at considerable depths,[3] and many other cases are recorded of the finding of remains in similar deposits. There are also many instances of equine and domesticated animals' remains from caves and prehistoric dwellings, such as crannoges.[4]

The only evidence in connexion with the discovery of remains of *Hippopotamus* in Ireland rests on a single canine tooth said to have been found near Carrickfergus in 1837. I have seen a well executed drawing which is reported to be of this tooth, by the late M. Du Noyer, in the office of the Geological Survey of Ireland. On submitting a copy to Dr. Moore, F. L. S., Naturalist to the Survey, when the discovery was made, he assured me that the above was a true representation of the tooth in question. The specimen, however, is lost, and the circumstances connected with the discovery not being altogether satisfactory, it appears to me prudent to allow the Hippopotamus a place for the present among the doubtful Irish mammals.[5]

The Wild Hog (*Sus scrofa*).

Remains of the Hog are found in caverns, bogs, and crannoges, &c., in connexion with domestic animals, and there are records of its existence in a feral state in Ireland,[6] but I can find no traces of its contemporaneity with the Mammoth and other pleistocene mammals. Nor is there satisfactory evidence of any feral Bos having been indigenous to Ireland.[7] Historians mention wild cattle, but possibly

[2] Carte, *Journal Royal Dublin Society*, vol. ii., p. 11. Adams, *Trans. Royal Irish Academy*, vol. xxvi., p. 215.

[3] Owen, *British Fossil Mammals*, p. 391.

[4] Bryce, *Report British Association*, 1834, p. 658. Wilde, *Proceedings of the Royal Irish Academy*, vol. i., p. 420.

[5] Dr. Moore makes a mistake in calling it "an Elephant's tooth" in a letter quoted by Professor Hull, *Journal of the Royal Geological Society, Ireland*, vol. iv., p. 61. The tooth is said to have been found by a son of the well-known Mr. Doran, who collected natural objects, and disposed of them to the officers of the Geological Survey of Ireland.—A. L. A.

[6] Wilde, *Proceedings of the Royal Irish Academy*, vol. vii., p. 208. Giraldus

these were only domesticated animals run wild.[8] Remains of *Bos longifrons* are very plentiful in bogs, river, and lake deposits, along with Sheep, Goats, Horse, Red Deer, Dog, and Fox.[9] It has also been discovered in ancient dwellings, such as crannoges, raths, &c.,[10] and many crania showing their frontals battered in by the poll-axe from these situations, and from other prehistoric dwellings, are preserved in the Museum of Science and Art, Dublin, but I have failed in procuring proofs of its existence as a feral species.

THE IRISH ELK (*Cervus megaceros*).

Enormous quantities of remains of this Deer have been found in sub-turbary deposits, and occasionally in river gravels throughout the island. None of the bones, as far as I have seen, show that either man or beast preyed on the animal. The remarkable incisions frequently observed on its bones from the shell marl are, beyond doubt, as pointed out by Carte, Jukes,[11] and others, the result of friction of opposing surfaces of bones during probable oscillations of the superincumbent bog. This Deer probably existed at the same time with the Cave or Grisly Bear, seeing that remains of the latter have been met with in shell marl under peat of possibly the same age; and there is evidence of its contemporaneity with the Reindeer.[12] The fact that heads of females and hornless heads of Stags are rarely found, whilst cast antlers are not uncommon, may be owing to the absence of the stupendous appendages which would have always greatly interfered with the animal when swimming, as it also assuredly placed him at a disadvantage in the forest.

Perhaps, therefore, these accidents occurred at seasons when the sexes were separated, and to all appearances when the horn was in its prime, which would be at the rutting season. A fine head and horns of Reindeer was found by Mr. Moss in lacustrine deposits under bog at Ballybetagh, County Dublin;[13] and quite recently Mr. Williams, Taxidermist, Dame-street, showed me an antler discovered by him in the above situation. In both cases they were associated with, or near to, enormous quantities of remains of *Cervus megaceros*. Taking the explorations made by Messrs. S. & J. Moss, and the two years' explorations lately carried out by Mr. Williams, it is estimated that, in a space not exceeding one hundred yards, considerably over a hundred crania of this Stag have been exhumed.[14]

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[8] Ball, *Proceedings of the Royal Irish Academy*, vol. ii. 541; and Wilde, *Idem*, vol. vii., p. 183.

[9] Du Noyer, *Journal of the Geological Society, Dublin*, vol. i., p. 248; and Ball, vol. i., p. 253.

[10] Wilde, *Proceedings of the Royal Irish Academy*, vol. i., p. 426.

[11] *Journal of the Royal Geological Society of Ireland*, vol. i. p. 152; and vol. [illegible] p. 127.

[12] Oldham, *Journal of the Geological Society, Dublin*, vol. iii., p. 252.

[13] *Ibid.*

Notwithstanding reiterated assertions to the contrary by every competent Irish observer, and by Owen in the *British Fossil Mammals*,[15] the error that remains of *C. megaceros* have been met with in peat overlying the shell marl and clays continues to be propagated. It is stated by Dawkins and Sandford in their *Monograph on British Pleistocene Mammals*,[16] published by the Palæontographical Society, that the *Cervus megaceros*, *C. tarandus*, *C. elaphus*, and *Bos longifrons*, have been found associated in peat in Ireland. Now, although remains of the Red Deer and Short-horned Ox are very plentiful in the peat, there is not, as far as I can discover, a single properly authenticated instance of exuviæ of either of the other two Deer having been found in the Irish turbaries overlying the shell marl and clays in which they are embedded.

A descriptive osteology of this Deer appears to me a desideratum, and more especially considering the abundance of its remains, and the excellent states of preservation in which they are met with in Ireland.

The Reindeer (*Cervus tarandus*).

The evidences of the Reindeer in Ireland were first recorded by Oldham;[17] it seems requisite, however, as far as possible, to enumerate the stratagraphical conditions under which the different discoveries were made:—

1. Two almost perfect heads with horns were found in shell marl under bog at Ballyguiry, near Dungarvan, county Waterford.[18]
2. The head and horn referred to in connexion with the Irish Elks' remains from Ballybetagh, county Dublin, were found in a clay overlying granitic boulders, and under peat.
3. A superb head, with mandible and horns, was found under peat at Ashbourne, in the county of Dublin.[19]
4. Several shed antlers, with a fragment of a skull and horn, were dredged from the bed of the Shannon, near Limerick.
5. A skull was found in the mud of Lough Gur, county Limerick.
6. A large number of remains, representing at least thirty-five individuals, were found in Shandon cave, near Dungarvan, associated with bones of the Mammoth, Grisly Bear, Wolf, Fox, Horse, Red Deer, and Hare.[20]

All these specimens are either in the Museum of Trinity College, or in the Museum of Science and Art.

The noteworthy character of the horns of all these finds is the

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[15] Page 464.
[16] Page xiii.
[17] *Journal of the Geological Society, Dublin*, vol. iii., p. 252.

uniformity as regards the beam, which is slender and round, as obtains in the English specimens, and the recent Reindeer of Norway, as compared with the flattened antlers of the Siberian stock. The presence of Reindeers' and Horses' bones in the surface as well as the deeper deposits of Shandon cave might indicate that they survived the Mammoth and Bear in Ireland.[21]

Remains of the Red Deer have been found in shell marl and other sub-turbary deposits of Ireland, but in by far the greatest abundance in the peat. Its presence in Shandon cave with the fauna just mentioned, and association with the Irish Elk, make it contemporaneous with all the pleistocene Mammals.[22] I have not seen Irish antlers of the maximum dimensions of the horns from English cave and river deposits.

There is no valid proof whatever that remains of the Elk (*Cervus alces*) have been found in Ireland. The horn referred to by Thompson,[23] and now in his collection at Belfast, is clearly that of a recent Elk.

THE MAMMOTH (*Elephas primigenius*).

The presence of this Elephant in Ireland is confirmed by the following discoveries:—

1. The teeth of a young individual were found in Cavan, in 1715.[24]
2. A rib, possibly of an Elephant, is figured by Smith, who states that it was dug up near Whitechurch, in the county of Waterford.[25]
3. Nearly an entire skeleton of an Elephant, with the antepenultimate molars entire, was discovered in Shandon cave, near Dungarvan, in the county of Waterford, in connexion with remains of Reindeer, Red Deer, Wolf, Fox, *Ursus fossilis*, Horse, and Hare. These remains are now in the Museum of Science and Art, Dublin.[26]
4. There is a nearly entire right humerus, No. 30, 531 of the Palæontological Collection of the British Museum, recorded as having been dredged up in the Bay of Galway. It is covered with Cirripedia belonging to the genus Lepas, and bears every indication of marine origin. The characters of the Mammoth's humerus are well shown in this specimen. The locality indicates the most western point in the European distribution of the species hitherto recorded.
5. I have lately been shown a photograph of portion of a molar of this Elephant by the Rev. Dr. Grainger, D. D., of Browshane, who states that he found it sticking in a marine deposit containing recent shells, near Corncastle, county Antrim. He further informs me that

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[21] Adams' Report on the Exploration of Shandon cave; *Transactions of the Royal Irish Academy*, vol. xxvi., p. 215.

[22] *Transactions of the Royal Irish Academy*, vol. xxvi., p. 224.

[23] *Report of the British Association*, 1840, p. 362.

[24] Molyneux, *Philosophical Transactions*, vol. xxix., p. 367.

[25] Smith, *History of Waterford* [1741], p. 81. Plate 2; figs. 1, 2, and 3.

the other instances referred to by him in his communication to the British Association now turn out to be doubtful.[27] The above are the only properly authenticated instances of the discovery of Mammoths' remains in Ireland (as far as my investigations extend).

Grisly Bear (*Ursus fossilis, sive ferox*).

The Irish ursine remains as determined by Ball, Carte, and others,[28] are stated to belong to the *Ursus maritimus, U. spelæus, U. ferox,* and *U. arctos.*

1. As regards *Ursus maritimus*, the data on which the determination was established comprise a humerus, femur, and fibula, besides portion of the atlas and axis; the two latter, strange to say, display complete ankyloses of their articulations. These bones were found in the mud of Loch Gur, in the county of Limerick, and are at present in the Museum of Science and Art.

In comparing the long bones with similar specimens belonging to the Polar Bear, they appear to me to differ from the latter in precisely the same characters as distinguish the bones of the Brown, the Grisly and the extinct cave Bears from the Polar Bear. These points of distinction as regards the latter have been clearly pointed out by Owen,[29] and refer to the (*a*) stoutness of the bones of the Polar species; (*b*) the size and configuration of the internal condyle of the humerus, (*c*) the position of the deltoid ridge; (*d*) the position of the lesser trochanter of the femur. In all these characters the Loch Gur bones disagree with the Polar, and agree with the Brown, Grisly, and Cave Bears, whose long bones are much alike. From the large dimensions of the specimens in question, they seem to belong in all probability to the *Ursus fossilis* of Goldfuss, now generally supposed to be identical with the recent *Ursus ferox*.

The proximal epiphysis of the *humerus* is wanting. The length of the remainder of the bone is 14½ inches. The breadth of the distal articulation is 3·4 inches; maximum width at the distal extremity 5 inches. Unfortunately, the supinator ridge has been destroyed close to its insertion, and prevents me ascertaining the angle made by it with the shaft. The antero posterior diameter at the middle of the deltoid ridge is 2·2 inches; the *femur* is entire, and 18·8 inches in length; the girth midshaft is 5 inches; breadth of the proximal extremity is 5 inches, and the distal 4 inches; the articular surfaces of the latter are 3·7 inches in breadth; the *fibula* is 13 inches in length, and presents the usual variable characters of that bone.

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[27] *Report of the Belfast Meeting of the British Association*, 1875. "On the Post tertiary Fossils of Ireland." By the Rev. Dr. Grainger, D. D.

[28] Ball, *Proceedings of the Royal Irish Academy*, vol. iv., p. 416. Carte, *Jour-*

2. A superb cranium without the mandible is now in the possession of the Earl of Enniskillen, who has kindly furnished me with the following particulars regarding its discovery. It was given to him by Mr. Young, of Monaghan, who told him that he received it from a navvy, and that the latter found it near Ballinamore, in the county of Leitrim, when digging the Shannon and Erne Canal.

The exact stratagraphical position is therefore wanting, but from the light colour of the specimen as compared with the black colouring of the bones from the mud of Loch Gur, it may be presumed that the skull was found in the shell marl, or else the sub-lacustine clay.

The only teeth remaining are the canines and last molar. The latter is 42 × 22 millimetres, and has the contracted posterior of the Grisly and the *Ursus fossilis* of Goldfuss. The zygomatic arcade is not so broad comparatively, nor are the posterior nasal openings so wide as in *Ursus arctos*. In these two particulars the specimen coincides with crania of the Grisly and *Ursus fossilis*. It differs from *Ursus spelæus* or the gigantic cave Bear in the shape of the last molar and size of the posterior nares, which are apparently narrower in the latter than in any of the foregoing.

The maximum length of the skull is 15 inches, and greatest width 9½ inches. Mr. J. Allen states that, out of crania of eight recent Grisly Bears examined by him, five were 14½, three over 15, and one was 16 inches in length. The maximum breadth of none of these, however, attains to that of the Leitrim skull, the width of the largest being only 8½ inches.[30]

3. Nearly an entire skeleton was found *in situ* in Shandon cave, in conjunction with the exuviæ of the Mammoth, Hare, Reindeer, Red Deer, Wolf, and Fox. The bones are enumerated by Dr. Carte, F.L.S., in his Report on the Shandon remains, and referred by him to *Ursus spelæus* and *Ursus arctos*.[31] The specimens are in the Museum of Science and Art.

The cranium is in fragments, but several molars and the left ramus of a very aged Bear, besides a fragment of a right ramus, evidently of a larger individual, remain. There is a diseased condition of the left ankle-joint, whereby the distal extremity of the fibula and corresponding surface of the tibia show extensive exostosis, which must have greatly impeded the movements of the animal as far as its predaceous habits were concerned; however, the Grisly Bear of North America, like its Brown congener, can subsist entirely on vegetable food. All the teeth of the above are larger than any of *U. arctus* I have seen.

The fragments of the maxillæ show the sockets of the small premolars as in the Leitrim skull, whilst the 4th p. m. is bitubercular, and

the ultimate has the contour of that of the Grisly and *Ursus fossilis*. The dimensions of the crown of this tooth are 40 × 24 millimetres, and the penultimate molar 24 × 20 millimetres.

The mandible includes the canine much injured sockets of the 1st p. m.; the sockets of 1st and 3rd, and portion of the 4th p. m.; the sockets of 1st and 2nd, and the ultimate molar are entire, but very much worn; it is rounded behind, as in *Ursus fossilis*, the same part being usually more angular in *Ursus arctos* and the gigantic cave Bear (*Ursus spelæus*).

The dimensions of this ramus, compared with that of a very old individual of *Ursus ferox*, show it to have belonged to a larger individual. There are seemingly no other points of distinction in this specimen, but the fragment of the articular extremity of the other ramus shows the thick incurved angular process apparently more pronounced, as in *Ursus fossilis* and *U. ferox*, than in *U. arctos*.

The other bones referred by Carte to *Ursus arctos* are an atlas, 2 cervical, 2 dorsal, and 2 lumbar vertebræ, with fragments of spinous processes and ribs. None of these appear to me to present morphological characters of importance. As regards dimensions, however, they represent a large Bear, as compared with recent species. The atlas, for example, gives the following:—

Height of the arch inferiorly, . . .	1·$\frac{5}{16}$ inches.
Vertebral foramen, ...	1·8 × 1·5 inches.
Anterior articular surface, . . .	1·11 × 1· inches.
Posterior articular surface, . . .	1·3 × 1· inches.

The long bones agree in their characters and dimensions with the usual specimens of *Ursus fossilis*, but the femur is fully an inch and a-half shorter than the Loch Gur specimen, which doubtless belonged to a very large Bear. As compared with the elements of a skeleton of an aged Grisly in the Museum of the Royal College of Surgeons of England, they indicate a much larger animal, the humerus being one and a-half inches, the femur one inch, and the tibia one and a-quarter inches longer.

These ursine remains from Shandon cave seem to me referrible to one species, and are indistinguishable from similar parts of *Ursus fossilis*, and *Ursus ferox*.

4. Two crania now in the Museum of the Philosophical Society of Leeds are stated to have been found seven feet under ground in a cut-away bog at Ballymahon, on the borders of Longford and Westmeath.[32] The teeth and mandibles are wanting in both. The skulls show the sockets of the first and third premolars. The zygomatic arcade is like the others just described, and the posterior nasal open-

in size, and indicate a female and an old male, as surmised from the sagittal ridge and frontal triangle.[33] The larger, although greatly exceeding the dimensions of any cranium of *Ursus ferox* or *Ursus arctos* with which I have compared it, is three-fourths of an inch shorter than the Leitrim skull; at the same time there can be little doubt but that all the three belong to the same species.

5. A cranium without mandible; No. 28,906 of the Palæontological Collection in the British Museum is stated to have been found "seven feet below the surface in alluvial deposits under bog oak trees at Clonbourne, King's County."[34]

A portion of the left zygoma is lost. The two canines and the fourth premolar and first and second true molars are preserved in the left maxilla, and the ultimate grinder in that of the right side. The molars and alveoli show indications of carious disease. The skull may have belonged to an aged female, or a small male. It is an inch and three quarters shorter than the Leitrim specimen, with which, and the Shandon one, it agrees in the cranial characters and the last molar; whilst the fourth p. m. is also biturbercular, thus correlating all their points of distinction.

6. A cranium, in the Museum of Science and Art, Dublin, was discovered "in cutting away a new channel for the Boyne above Leinster Bridge, in the county of Kildare." Other bones are stated to have been found at the same time, but have not, however, been preserved.[35] The skull is dark, and, like the bones from the deposits of Loch Gur, contrasts in that respect with the other skulls from the shell marl and clays. Moreover, this skull is much smaller than any of the foregoing, being two and a-half inches shorter than the Leinster cranium. The coronal ridges are not well develoved, and although the sutures are closed, it evidently belonged to a female or adolescent male. The zygomata, incisors, ultimate true molar, together with the first and third of the right maxillæ, are wanting. The alveolus of the first premolar of the right side is completely obliterated, which is not by any means common unless in the gigantic cave Bear, where it is very generally absent.

The fourth premolar and successional molars are present in the right maxilla, and are not much worn. The last molar has the round posterior portion of the crown slightly contracted, with the three cusps on the outer side of the grinding surface, and is much of the same size as in *Ursus fossilis* and *U. ferox*. It is 34 × 20 millimetres. The contour of the zygoma cannot be ascertained, but the posterior nares are wider than usually noticed in *Ursus ferox*. This cranium

[33] Mr. Denny, from such obvious discrepancies in the cranial ridges, has described them as specific distinctions, whereas they are mere conditions relating to age and sex.

[34] *Catalogue of the Industrial Exhibition of Dublin*, 1853, p. 152.

has been supposed, on account of its small size and dark colour, to have belonged to the *Ursus arctos;* but although smaller by a good deal than the usual cranium of *Ursus fossilis*, it is equal to that of a Grisly Bear, with which it is closely related in having a tricuspidated last molar.

Mr. Busk, F.R.S., referring to several of these crania in his Report on Buxham cave,[36] unhesitatingly places them with *Ursus fossilis sive Ursus ferox fossilis*, and, as far as I have seen, this is the only form represented by the ursine remains hitherto reported from Ireland. The absence of the Brown Bear, or rather of any cogent evidence of the animal either in a fossil state or historically,[37] is noteworthy as compared with the Brown Bear of Scotland and England. But the relationship between *Ursus ferox* and *Ursus arctos* is very close, not only as regards the fossil but also the recent individuals; so much is this the case, that individuals are indistinguishable by external appearances; and as to their dentitions and osteologies, Mr. Busk shows in his very exhaustive account of the Quaternary fauna of Gibraltar,[38] that the ursine remains from Genista cave indicate that they belonged to a Bear "closely related to *Ursus fossilis sive priscus*, or to a form intermediate between it and the *Ursus arctos var. isabellinus*." Indeed no recent carnivore presents more well-marked varieties than the *Ursus arctos*, as differentiated by external colouring, but the isabelline variety of the Himalayas and Turkestan presents a more warty or porcine-like grinding surface of its molars than is ordinarly observed in the species elsewhere. This condition, I have no doubt, from extensive observations of the above variety in its native haunts, is the result of altered conditions of life; inasmuch as the isabelline Bear, unable to capture the agile animals of the Alpine regions it frequents, is driven to subsist almost entirely on roots of plants, and other vegetable food; hence its timidity as compared with the *Ursus ferox*, which still continues to follow the Bison.

How far the wider posterior nares in the Brown Bear, as compared with *Ursus ferox*, and in particular *Ursus spelæus*, may be the result of natural selection, giving a more extended surface for smell, on which the recent Brown Bear depends almost entirely in discovering the presence of his most deadly enemy, and also in supplying a condition favourable for free respiratory action, under the trying circumstances in which the animal is now placed, is a point on which it seems to me one is free to speculate, when we come to consider the severe struggles for existence to which an omnivorous plantigrade like the tardy Bear has been subject to throughout the Tertiary Epoch.

[36] *Philosophical Transactions*, vol. clxiii., p. 632.

[37] Bede, *obiit* 735, A. D., asserts that the Wolf and Fox were the sole large car-

THE WOLF (*Canis lupus*).

The Wolf is included among the Irish pleistocene Mammals, as shown by the discovery of bones and teeth in Shandon cave along with the Mammoth, Reindeer, Horse, &c.[39] It was only exterminated at the beginning of last century.[40]

Vulpine remains identical with the recent Fox, *C. vulpes*, were found in Shandon cave with the foregoing and the other extinct mammals already enumerated. I found its teeth and bones also in the more superficial deposits, accompanied by bones of Horse, Reindeer, Red Deer, Hare, &c.

ALPINE HARE (*Lepus variabilis*).

A cranium and several bones of a Hare found in Shandon cave, along with vertebræ and molars of the mammoth, show shorter and stouter shafts of the long bones than appear in the fossil Hares from Kent's Hole, and the recent *Lepus timidus*, which is not known to have been indigenous to Ireland. The probability therefore is that, as the same parts of *Lepus variabilis* display similar characters, and the so-called variety *L. Hibernicus* being the Hare of the island, it has appeared to me that the above might belong to the latter.[41] Traces of the teeth of a Rodent of about the dimensions of a Rat were evident on the Mammoth, and other remains from the cave of Shandon, but none of its remains were found.

A comparison of the Irish and Scotch lists of Post-tertiary mammals shows an absence in Ireland of the Elk, Roebuck, Urus, Beaver, Hare, Water Rat, Red Field Vale, Meadow Mouse, Common Shrew, and Mole.

The Bear of Scotland was presumably, and very probably, the *Ursus arctos*, but none of its remains have been preserved; considering, however, its affinities to *Ursus fossilis*, the absence of the Brown Bear from the Irish fauna is not very important. The Wild Cat, Weazel, and Foumart are also absentees.

As compared with England and Wales, there is a marked absence in both Scotland and Ireland of the two species of Rhinoceros, Hippopotamus (?), Bison, Musk Sheep, and ancient Elephant, pouched Marmot Pika, Lemmings, Dormouse, Scandinavian Vole, Champagnol, The Lion, Sabre-toothed Lion, Panther, Lynx, Caffre Cat, Arctic Fox, Spotted Hyæna, Glutton, and gigantic cave Bear.

It is important to observe that all the living and extinct mammals of Ireland, with the exception of the *Ursus fossilis*, have been recorded also from Scotland; that is to say, there is no mammal, recent or lost, in the island which is not also found in Scotland.

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[39] Author, *Transactions of the Royal Irish Academy*, vol. xxvi., p. 227.

To the absence of the Lions, Panther, Spotted Hyæna, and gigantic cave Bear may be owing the seeming prevalence of the Irish Elk in Ireland; but at the same time it is important to bear in mind that the quantities of remains of this ruminant have been obtained under conditions clearly indicating that the individuals had been drowned in lakes which, during the Post-glacial Period, must have been extremely plentiful throughout Ireland, whose physical aspect would have been then inimical to such as the Marmot, Lemmings, Pika, Bison, and Urus, which delight in broad pastures and grassy uplands.

But the probability is, that the migration came from Scotland, and that there was a land communication between the two countries at the close of the Glacial Period, by which the greater portion of the mammals that had found their ways to Scotland crossed to Ireland. Irrespective of the soundings between northern Ireland and south-western Scotland, there is evidence of the remains of the Mammoth, Reindeer, Irish Elk, and Horse having been found in similar deposits in Ayrshire, Renfrewshire, Lanarkshire, and bed of the Clyde. The Irish Elk has been found in the Isle of Man, and a jaw and teeth of the Mammoth in the harbour of Holyhead, whilst on the other hand the caves of Glamorganshire have produced nearly all the English Post-glacial mammals not met with in Scotland or Ireland; consequently, if an uninterrupted land communication existed between south-western England and Wales, and Ireland, at the close of the Glacial Period, we should expect to find remains of these characteristic mammals, which is not the case. Again, the animals we do find are, for the most part, vagrant species such as the Horse, Mammoth, Reindeer, Red deer, Bear, Wolf, and Fox,[42] so that the severance took place before the slow travelling Mole Beaver, the forest-haunting Elk and Roebuck had time to arrive. It has been suggested by my friend Professor Hull, F. R. S.,[43] that there may have been a narrow channel between the islands, and that the mammals swam across, or arrived on ice-rafts: but looking over the list of the fauna of Ireland, it seems to me that nothing short of a direct land union will meet the requirements of the case.

Excluding the Cetacea, marine Carnivora, and the Chieroptera, it will be found that out of twenty-eight recent species affecting England and Wales, twenty-six are indigenous to Scotland, and fifteen to Ireland; whereas of thirty-two extinct species hitherto recorded for England and Wales, ten have been found in Scotland, and only seven in Ireland.

[42] According to Thompson, out of eleven British Amphibians and Reptiles, only five have been found in Ireland, including the Agile Lizard, two Tritons, and two

XVII.—On the Formation and Composition of some Complex Oxides of Cobalt and Nickel. By Thomas Bayley, Associate Royal College of Science, Ireland.

[Read, June 25, 1877.]

While preparing standard solutions of nickel and cobalt salts for the purposes of a research on the colorimetric relations and on the colorimetric estimation of those metals, I was endeavouring to use a modification of the method of estimating nickel and cobalt, indicated by Bunsen[1], depending for their determination on the iodine liberated by the higher oxides of these metals in contact with hydrochloric acid, and potassium iodide. The method was as follows:—The solution of the nickel or cobalt salt was made alkaline by soda and then mixed with excess of sodic hypochlorite obtained by the action of cold dilute sodic carbonate on fresh bleaching powder.

After allowing the slightly warm solution of nickel or cobalt to stand some time, so as to ensure complete oxidation, the temperature was raised until brisk effervescence ensued, and the solution allowed to remain at that temperature until the excess of hypochlorite was decomposed. When the evolution of oxygen had ceased, the liquid was boiled for about half an hour. I found that by this process it is easy to destroy all matter, except the oxide, capable of liberating iodine on treatment with potassic iodide and hydrochloric acid. The solution having been cooled, it was mixed with excess of potassic iodide, and then with enough hydrochloric acid to dissolve the suspended oxide. The liberated iodine was then estimated by a standard solution of sodic thiosulphate ($Na_2 S_2 O_3$).

In the first experiments I used a standard solution of nitrate of nickel, and calculated the nickel from the iodine set free according to the following equation:—

$$Ni_2 O_3 + 6HCl = 2Ni Cl_2 + Cl_2 + 3H_2O.$$

The results were not satisfactory, as will be seen from the following Table:—

Nickel used.	Nickel found.
grams.	grams.
·1570	·1437
·1570	·1580
·1570	·1465
·1570	·1568
·1570	·1639
·1570	·1541

Besides these analyses there were several which yielded a far less quantity of nickel. The same method was then applied to cobalt, with this difference, that the solution was boiled only for a few minutes, as I found that length of time sufficient for the decomposition of the last traces of hypochlorite. The amounts of iodine liberated were much greater than would be due to the oxide Co_2O_3, while they agreed perfectly with an oxide Co_3O_5, thus:—

Cobalt used.	Iodine liberated.	Theory of Iodine for Co_3O_5.
grams.	grams.	grams.
·1865	·5338	·5343
·1865	·5380	·5343
·1865	·5328	·5343

I now repeated the experiments with nickel, taking care to boil the liquid only a minute or two. In one or two instances it was not boiled, but the precipitate filtered off and washed. The results were as follows:—

Nickel used.	Iodine liberated.	Theory of Iodine for Ni_3O_5.
grams.	grams.	grams.
·1570	·4428	·4521
·0785	·2263	·2260
·1835	·5318	·5284
·1570	·4490	·4521

With a mixture of ·1863 gram. cobalt, and ·1835 gram. nickel:—

Iodine found.	Theory for Iodine due to Ni_3O_5 & Co_3O_5.
grams.	grams.
1·0532	1·0627

In the last case the oxides were not boiled, but the solution was allowed to stand over the steam bath for a few hours.

With solutions of known quantities of nickel, I now made the following experiments. The solution with the suspended oxide was boiled for some hours

Nickel used.	Iodine found.	Theory of Iodine. for Ni_3O_4.
grams.	grams.	grams.
·1835	·2009	·2642
·1835	·1812	·2642
·1835	·2321	·2642
.1835	·3310	·2642
·1835	·2830	·2642
·1835	·3765	·2642
·1835	·1069	·2642

In the last experiment the solution was boiled for a few days.

A quantity of cobalt nitrate was now mixed with sodá and sodic hypochlorite, and allowed to stand in a warm place until effervescence had ceased. The precipitated oxide of cobalt was then well washed with warm water and dried, till constant, under the air pump, over strong sulphuric acid.

A sample of this oxide was then submitted in succession to various temperatures. The results were as follows:—

	grams.		grams.
Oxide taken, ...	·9278	(Co_3O_5, $4H_2O$).	
Oxide dried at 100° C, .	·8760	Theory for Co_3O_5, $3H_2O$, .	·8770
,, ,, ,, 138° C, .	·8223	,, ,, Co_3O_5, $2H_2O$, .	·8263
,, ,, ,, 310° C, .	·7548	,, ,, Co_3O_5, H_2O, .	·7756

After this experiment there was an appearance of change on the surface of the oxide.

	grams.		grams.
Oxide after ignition to redness, .	·6840	Theory for Co_3O_4, .	·6798.

Another portion of the same sample:—

	grams.		grams.
Oxide dried at 100° C, .	·4070	(= Co_3O_5, $3H_2O$).	
Oxide after ignition to redness, .	·3125	Theory for Co_3O_4,	·3154.

Another sample prepared in the same way, but left longer over the air pump:

	grams.
Oxide taken dried over H_2SO_4 .	·7083.

dry oxygen, and the water given off collected in a tube filled with calcium chloride. The oxide was afterwards ignited to bright redness in air.

		grams.
Calcium chloride tube,	.	65·3250
Calc. chl. tube + water,	.	65·4680
		·1430 = OH_2

		grams.
Oxide after ignition in the tube,	.	·5493
Oxide after ignition in air,	.	·5293

The results of this experiment are compared below with the theory for Co_3O_5, $4H_2O$. For a reason which will be seen further on, I have added the theory for Co_2O_3, $3H_2O$.

Theory for Co_3O_5, $4H_2O$.			Found.		Error.
		grams.	grams.		grams.
$4H_2O$,	.	·1549	·1428	.	− ·012
Co_3O_5,	.	·5534	·5493	.	− ·004
Co_3O_4,	.	·5190	·5293	.	+ ·013

Percentages.

	Co_3O_5, $4H_2O$.	Found.	Co_2O_3, $3H_2O$
OH_2, .	21·86	20·16	24·54
Co_3O_4, .	73·27	74·68	73·05
	95·13	94·84	97·59

Winkelbleck obtained an oxide in the same way as I prepared my samples, only that he boiled his with strong potash before washing it. He dried his oxide over strong sulphuric acid. According to him, the formula is Co_2O_3, $3H_2O$. His results were as follows:—

	Per Cent. (1)	Per Cent. (2)	Per cent. Theory.
2Co, . .	53·83	53·93	53·64
3O, . .	21·62	21·46	21·82
$3H_2O$, . .	24·26	24·61	24·54

The question, which is the true formula of the oxide I obtained, is determined by the amount of iodine liberated by the oxide on treatment with potassic iodide and hydrochloric acid. According to the formula $Co_2\ O_3\ 3\ H_2O$, there should be liberated ·402 gram by ·1865 gram of cobalt; according to the formula Co_3O_5, 4 H_2O, ·5343 grams should be liberated. I found in three experiments ·5338, ·5380, and ·5328.

When the oxide Co_3O_5, 4 H_2O, obtained as described above, is boiled for an hour or two in the solution in which it is precipitated, and the amount of iodine liberated then estimated, the result points to the formation of the oxide $Co_{12}O_{19}$ intermediate between Co_3O_5 and Co_2O_3.

Co. taken.	Theory of I. for Co_3O_5	Theory of I. for Co_2O_3		Found.
gram.	gram.	gram.		gram.
·1865	·5343	·4007	(1)	·453
	Mean.		(2)	·463
	·4676		(3)	·462

	Theory for $Co_{12}O_{19}$ Iod.	Found. gram.
·0620	·1566 gram.	·1556

In the last experiment a fresh solution of cobalt, and a fresh solution of potassium bichromate (to standardise the thiosulphate), were used.

A quantity of the oxide of cobalt prepared by precipitating with potash and sodic hypochlorite, and *boiling for some hours*, then washing and drying over sulphuric acid *in vacuo*, was submitted to a current of air at a low red heat, and the water collected and weighed in a calcium chloride tube. The oxide was afterwards ignited to bright redness in air.

	grams.
Oxide dried over H_2SO_4,	·7455
Oxide after ignition in tube ($Co_{12}O_{19}$),	·6255
Oxide after ignition in air (Co_3O_4),	·5975
Calcium chloride tube + OH_2,	65·5900
Calcium chloride tube	65·4615

	Theory for $Co_{12}O_{19}$, 11 H_2O. grams.	Found. grams.
OH_2	·1218	·1255
$Co_{12}O_{19}$	·6236	·6255
Co_3O_4	·5940	·5975

Percentage.

	Theory for $Co_{12}O_{19}$, 11 H_2O	Found.
OH_2	16·34	16·83
$Co_{12}O_{19}$	83·65	83·90

On attempting to prepare Ni_3O_5 in the dry state by precipitating, washing, and drying *in vacuo*, I found that the moist precipitate gave off oxygen as soon as the liquid in which it was precipitated was removed. The moist precipitate was allowed to stand some days, and then left over the air pump for about a week, in order to allow time for this change to be complete. Owing to some interruption, I have as yet had time to prepare only one sample by this means. The results of the analysis agree closely with the formula Ni_8O_{11}, 9 H_2O, one-ninth of the water being lost at 100°C.

	Oxide taken. grams.	Theory of Iodine for Ni_8O_{11}, 9 H_2O. grams.	Found. grams.
Dried over H^2SO_4	·1705	·1607	·1661
,, ,, ,,	·2012	·1896	·1895
,, ,, ,,	·2375	·2238	·2243

	Oxide taken. grams.	Theory of Iodine for Ni_8O_{11}, 9 H_2O. grams.	Found. grams.
Dried at 100°C.	·2080	·2005	·2026

The water in this oxide was determined by igniting the oxide in a platinum boat in a combustion tube, and weighing the water lost by means of a calcium chloride tube.

Oxide taken. grams.	Theory for Ni_8O_{11}, 9 H_2O.	Found. grams.
·8723	·1748 grm. OH_2	·1775

Per Cent.

OH_2	20·039	20·34

Per Cent.

	Theory for Ni_8O_{11}, 9 H_2O. grams.		Found. grams.
NiO	74·02	(1)	74·15
		(2)	74·29

Summary.

Under the influence of the hypochlorite solution nickel and cobalt form the oxides Ni_3O_5 and Co_3O_5. On boiling the liquid containing Co_3O_5 it loses oxygen, and passes to the form $Co_{12}O_{19}$, intermediate between Co_2O_3 and Co_3O_5. Under similar circumstances, Ni_3O_5 appears to decompose without forming stable lower oxides, although it is probable from the results that the formation of Ni_2O_3 is a stage in the process. The oxides Co_3O_5 and $Co_{12}O_{19}$ appear to be stable at a low red heat; they are distinguished from Co_3O_4 by a slight difference of colour. Co_3O_5 has the following hydrates:—

Co_3O_5, 4 H_2O (dried over H_2SO_4),
Co_3O_5, 3 H_2O (dried at 100°C),
Co_3O_5, 2 H_2O (dried at 138°C),

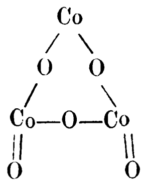
and probably,

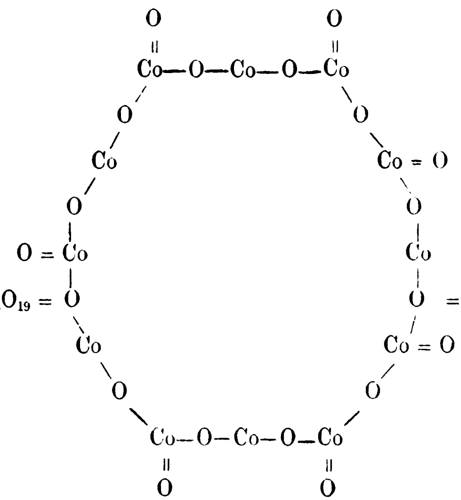
Co_3O_5, H_2O (dried at 300°C).

Ni_3O_5 decomposes while still moist when its precipitating liquid is removed by washing. In the one experiment which was made, the resulting dried compound agreed closely with the formula Ni_8O_{11}, 9 H_2O. I have found that, when Co_3O_5, 4 H_2O is treated with cold dilute nitric acid, part is dissolved with evolution of oxygen, and that part remains insoluble. I hope, in a future Paper, to give the results of some similar experiments undertaken for the purpose of determining the proximate constitution of these oxides.

It may at first sight appear that the formula $Co_{12}O_{19}$ is inadmissible on account of its complexity, but as the iodine method clearly shows that the oxide is exactly intermediate between Co_3O_5 and Co_2O_3, and as the formula $Co_{12}O_{19}$ is the simplest formula for such an oxide, it would seem that we must accept it, especially when we consider the tendency of cobalt to form compounds vieing in complexity with many of the products of organic chemistry. It may be that the application of the iodine method to the examination of the oxides of other metals would

what analagous to the well-known benzine ring of the aromatic carbon compounds. Thus:—

$Co_3O_5 =$  $= Co''O,\ 2\ Co^{IV}O_2$

$Co_{12}O_{19} =$  $= 5\ Co'O,\ 7\ Co\ \ O_2$

This investigation was conducted in the Chemical Laboratory of the Royal College of Science, Ireland.

	Bass's Ale.	Allsopp's Ale.	Foreign Double Stout.	Double Stout.	Guinness's Single Stout.
…INOID MATTER.	1st Estimation :— 333·2404	327·1731	574·0000	435·303	298·996
	2nd Estimation :— 340·5217	316·7365	549·6250	422·112	316·584
	Mean = 336·8810	321·9518	561·8125	428·708	307·790
… ACID, . . .	1st Estimation :— 95·9280	168·210	261·786	139·300	160·580
	2nd Estimation :— 96·1310	167·90	255·7058	147·000	160·090
	Mean = 96·0295	167·05	258·7409	143·150	160·335
…OL, ...	4383·4000 4365·9000 4374·6509	4478·5125 4443·8625 4461·1875	5128·2000	4643·100	3534·3000
. . . . .	19·125	18·375	123·110	111·088	85·600 79·829 82·715
… SOLIDS, . .	4884	3110	4374	5068	3838·5
…IC GRAVITIES,	1·0138	1·0144	1·01157	—	1·12438

XIX.—COMPUTATION OF TIDES AT FLEETWOOD.—RESULTS OF THEORY AND OBSERVATION. By JAMES PEARSON, M. A., Ex-Scholar (15th Wrangler), Trinity College, Cambridge.

[Read, November 12, 1877.]

IN resuming the consideration of the subject of the tides, it is not my intention to enter at any greater length into the theory which has produced results so closely in accordance with observation: it is sufficient for me to make some remarks on the principal cause of such discrepancies as are found to arise where tables have been used which are based upon that theory—and amongst these disturbing influences, the pressure of the atmosphere ranks foremost. A very simple process may be employed to establish this. It is found that, in the same month, but in different years, the same, or nearly the same, constituents have to be employed in computing a tide; and as like causes produce like effects in nature, the resulting tide ought to be the same in both cases. But it is not so, and the variation is found to depend on the height of the mercury in the barometer, or, more correctly, on the magnitude and direction of the gradients indicated in the weather reports issued in the newspapers. Another disturbing element is that which depends on the suddenness with which the pressure shifts its direction. Thus, a south-east wind rapidly changing into a south-west wind causes an unusual elevation of the level of the Irish Sea. Two examples may serve by way of illustration. In the first case there are exhibited two tides which have very nearly the same constituents, and which, in consequence of the atmospheric conditions being the same, give results both agreeing with observation. The heights are given in feet and inches.

CASE I.

	1876, Sept. 3, Morning Tide, Anti-lunar and Solar.					1877, Aug. 23, Morning Tide, Anti-lunar and Solar.				
	d.	h.	m.	ft.	in.	d.	h.	m.	ft.	in.
Moon's Transit, B, .	1	10	39	25	5	21	10	35	25	4
Corr. for Anti-lunar, .					+ 1					+ 1
Moon's Hor. Parallax,	54′	45″			− 7	54′	3″			− 11
Anti-lunar Declination,	18°	12′ N. des.			− 7	20°	41′ N. des.			− 10
Solar Declination, .		8° N.			+ 4		12° N.			+ 4
	24 8 obs.			24	8	24 0 obs.			24	0
	Bar. 29 9.	No wind				Bar. 29·8.	No wind.			

CASE II.

	1876, Sept. 10, Morning Tide, Lunar and Anti-solar.		1877, Aug. 21, Morning Tide, Lunar and Anti-solar.	
	d. h. m.	ft. in.	d. h. m.	ft. in.
Moon's Transit B, .	8 3 30	23 2	29 3 50	22 8
Corr. for Lunar, . .		+ 5		+ 5
Moon's Hor. Parallax,	57′ 53″ +	+ 7	55 50	− 3
Lunar Declination, .	20° 0′ N. asc.	− 4	19° 23′ N. asc.	− 2
Anti-solar Declination,	5° S.	+ 5	9° S.	+ 4
	24 3 obs.	24 3	23 7 obs.	22 11
	Bar. 29·7. No wind.		Bar. 29·6. Wind N.W., strong.	

It is to be observed that, in Case II., although the tide of September 10 has almost all its constituents more favourable to its development than those of August 31, still, in consequence of the atmospheric conditions, a higher tide results in the former case than in the latter.

In the computation of tides, the first thing which is of importance is, that we assign to each tide its proper classification. The transit which is to be employed, as a sort of standard transit from which tides are to be calculated, is the transit next but two preceding that transit which is nearest to the time of high water of the tide considered. This transit is, in fact, the transit B of Sir John Lubbock's Tables. The rule for determining the classification for the tides of the Irish Sea is as follows:—"Lower transits B are followed by lunar tides, and upper transits B by Anti-lunar tides. All transits B which take place between 23⅓ hours, and 11⅓ hours (apparent Greenwich time), give *morning* tides; and all between 11⅓ hours, and 23⅓ hours (apparent Greenwich time), give *evening* tides. All transits B, after 6 hours, and before 18 hours, are connected with solar tides; and all transits B, after 18 hours, and before 6 hours, with anti-solar tides."

A tabulated comparison of the results of theory and observation is appended, with remarks on the atmospheric conditions in explanation of such discrepancies as are found to occur in them.

TABULATED RESULTS.

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
August 8	M.	26·7	25·10	30·1, S. W.
	E.	25·2	24·5	
9	M.	26·5	25·10	30·1, W.
	E.	25·7	24·7	
10	M.	26·2	25·5	30·1, W. N. W.
	E.	23·11	23·7	
11	M.	25·4	24·9	30·3, E. S. E.
	E.	23·3	23·3	
12	M.	24·1	23·9	30·2, E. S E.
	E.	22·5	22·4	
13	M.	23·0	22·10	30·0, E. S. E.
	E.	21·1	21·6	
14	M.	21·5	21·7	30·0, W.
	E.	20·3	20·5	
15	M.	20·11	21·1	30·0, N. W.
	E.	21·0	21·0	
16	M.	21·8	21·9	30·0, E.
	E.	22·6	22·6	
17	M.	23·4	23·3	30·0, E. S. E.
	E.	24·10	24·10	
18	M.	25·6	25·4	29·9, E.
	E.	26·8	26·7	
19	M.	26·10	26·7	29·9, E. S. E.
	E.	28·2	28·2	
20	M.	28·0	27·9	29·8, N. E.
	E.	—	—	
21	M.	29·2	29·0	29·9, E. S. E.
	E.	28·3	27·9	
22	M.	29·1	28·9	29·9, W. N. W.
	E.	27·9	27·8	
23	M.	28·5	28·4	29·8, W. N. W.
	E.	26·10	26·9	
24	M.	26·9	26·11	29·8, W. N. W.
	E.	25·3	25·8	
25	M.	24·9	24·7	30·0, N. N. E.
	E.	23·5	23·5	
26	M.	22·10	23·2	30·0, S. W.
	E.	21·4	22·6	Strong wind, S. W. gale.
27	M.	20·9	21·6	29·1, W.
	E.	19·9	19·9	
28	M.	19·1	18·11	29·8, S. S. W.
	E.	18·9	19·4	Wind high.

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
Aug. 30	M.	18·10	19·3	29·6, W. S. W.
	E.	20·2	22·9	Wind high, S.; bar. 29·2.
31	M.	20·6	21·4	29·0, W. S. W.
	E.	21·9	22·6	
Sept. 1	M.	21·11	21·9	29·6, N. W.
	E.	23·10	24·1	
2	M.	23·5	23·4	29·8, N. N. E.
	E.	25·2	25·5	
3	M.	24·8	24·8	29·9, W. N. W.
	E.	26·3	26·3	
4	M.	25·9	26·2	29·5, E.
	E.	27·5	27·4	
5	M.	—	—	29·4, S.
	E.	26·6	26·6	
6	M.	28·0	28·0	29·4, S. W.
	E.	26·10	26·10	
7	M.	27·11	27·9	29·5, S.W.
	E.	26·4	26·4	
8	M.	27·2	26·10	29·6, W. N. W.
	E.	25·4	25·1	
9	M.	25·9	26·4	29·7, W.
	E.	24·3	24·3	
10	M.	24·3	24·3	29·7, W. N. W.
	E.	22·9	23·11	
11	M.	22·6	22·10	29·7, W. N. W.
	E.	21·2	21·7	
12	M.	20·8	20·7	29·8, N. W.
	E.	20·0	20·4	
13	M.	20·2	20·4	29·8, N. W.
	E.	20·9	20·11	
14	M.	21·5	21·6	29·8, W.
	E.	22·10	22·10	
15	M.	23·8	23·9	29·8, W.
	E.	25·4	25·4	
16	M.	25·8	25·5	29·7, S. E.
	E.	27·0	27·0	
17	M.	27·2	27·1	29·6, S.
	E.	28·6	28·7	
18	M.	27·11	27·9	29·7, S. W.
	E.	29·7	28·6	Bar. rising.
19	M.	—	—	30·0, W.
	E.	28·3	27·9	Bar. 30·1.
20	M.	28·6	28·1	Bar. 30·1, W.
	E.	27·7	27·3	
Sept. 21	M.	27·8	27·7	30·2, S. E.
	E.	26·6	26·5	

erva-ons.	
. in.	
6·4	30·0
5·3	
4·5	29·8
4·0	
2·6	Bar.
2·10	Bar.
1·3	29·5
9·9	
8·7	29·8
8·7	
7·6	29·6
8·8	
8·8	29·6
0·3	
0·5	29·4
2·0	
1·9	29·6
3·5	Gal
3·5	29·
5·1	Bar
4·5	30·1
6·4	
5·11	29·
7·9	
7·2	29·
8·4	
—	
7·4	29·
8·1	29·
7·2	
7·6	29·
6·6	
6·2	29·
4·11	
4·7	Ba
4·4	Ba
23·5	29·
23·1	
21·4	W.
23·3	29·
21·4	29·
22·6	
22·11	29·

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
Oct. 15	M.	26·0	25·10	29·7, S.
	E.	27·0	27·2	
16	M.	27·0	27·5	29·6, S. E.
	E.	28·3	28·3	
17	M.	27·8	27·8	29·6, S. E.
	E.	28·3	28·5	
18	M.	27·9	27·9	29·6, S. E.
	E.	27·10	27·9	
19	M.	—	—	
	E.	27·1	26·10	Bar. 29·8, S.
20	M.	26·6	26·1	Bar. 30. 0, S. E.
	E.	25·10	25·9	
21	M.	25·2	25·0	30·1, N. E.
	E.	24·10	24·2	
22	M.	23·7	23·4	30·2.
	E.	23·3	22·11	
23	M.	21·7	21·6	
	E.	21·9	21·9	
24	M.	20·2	20·2	30·1, S. E.
	E.	20·3	20·6	
25	M.	18·7	18·7	30·2, S. E.
	E.	19·3	19·4	
26	M.	17·7	17·6	30·3, S. E.
	E.	19·3	19·2	
27	M.	18·8	18·5	30·3, S. E.
	E.	20·5	20·3	
28	M.	20·1	19·10	Bar. rising.
	E.	22·0	21·7	Bar. 30·3, S. E.
29	M.	21·10	22·0	Settled.
	E.	23·9	23·5	30·3, S. W.
30	M.	23·6	23·6	30·2, N. W.
	E.	25·7	25·2	
31	M.	25·1	24·5	Bar. 30·3, W.
	E.	26·11	26·0	Bar. 30·4
Nov. 1	M.	25·11	25·7	Bar. 30·4, N. E.
	E.	27·5	27·0	
2	M.	26·6	26·6	30·3, N. W.
	E.	27·10	27·8	
3	M.	27·1	27·3	30·2, S. W.
	E.	—	—	
4	M.	27·7	27·5	30·3, W. N. W.
	E.	26·8	26·7	
5	M.	26·8	26·5	30·3, W.
	E.	25·9	25·11	
6	M.	25·5	25·5	30·3, W.
	E.	24·6	24·6	

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft in.	
Nov. 7	M.	23·11	23·8	Wind W., slight.
	E.	23·3	23·4	30·3, N. E.
8	M.	22·5	22·0	Bar. 30·2, S. E.
	E.	22·0	22·2	
9	M.	21·1	20·11	30·1, N. E.
	E.	21·6	21·8	
10	M.	21·3	21·0	Frost.
	E.	22·3	22·4	30·2, N. E.
11	M.	22·5	23·0	Bar. fallen.
	E.	23·4	23·9	29·9, S. E.
12	M.	23·6	23·0	
	E.	24·9	24·6	29·7, E.
13	M.	24·10	24·8	29·3, E.
	E.	25·7	25·3	
14	M.	25·7	25·8	29·6, E.
	E.	26·3	27·3	Bar. fallen, S. S. W.
15	M.	25·10	26·6	29·4, S. E.
	E.	26·3	26·7	
16	M.	26·1	26·4	29·3, E. N. E.
	E.	26·2	26·10	S. W.
17	M.	26·2	26·8	29·8, S.
	E.	—	—	
18	M.	25·7	25·7	29·8, S.
	E.	25·8	26·0	
19	M.	24·9	25·3	Bar. 29·7, S.
	E.	24·7	25·6	Gradients.
20	M.	23·4	24·5	Southerly.
	E.	23·4	24·0	29·7, S. W.
21	M.	22·3	22·5	
	E.	22·6	23·0	Bar. 29·9, W.
22	M.	21·0	21·4	30·1, S. E.
	E.	21·5	22·3	S.
23	M.	19·9	20·3	30·1, S. E.
	E.	20·8	21·3	
24	M.	19·3	19·3	29·8, S. E.
	E.	20·6	20·6	
25	M.	19·0	18·11	29·6, S. E.
	E.	21·0	21·2	
26	M.	20·0	20·2	29·5, S. E.
	E.	22·0	22·3	
27	M.	21·2	21·5	29·4, S. E.
	E.	23·2	22·11	Wind E., slight.
28	M.	22·7	22·8	29·3, N.
	E.	24·6	24·6	
29	M.	24·3	24·5	29·4, W. S. W.
	E.	25·10	25·10	
30	M.	25·7	25·8	29·5, S.
	E.	26·7	26·6	

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
Dec. 1	M.	26·10	26·11	Bar. fallen.
	E.	27·5	28·5	Bar. 29·2, S. E.
2	M.	27·5	27·6	
	E.	27·10	26·11	Gale N. E.; bar. 29·0.
3	M.	—	—	
	E.	27·8	28·6	Bar. fallen; wind S. W.
4	M.	27·8	28·5	Bar. 28·9.
	E.	26·11	28·5	Stormy.
5	M.	26·6	27·6	Bar. 28·5.
	E.	26·2	27·7	
6	M.	25·2	27·6	Gale S. W.
	E.	25·2	27·0	Bar. 28·9.
7	M.	24·3	25·0	Unsettled.
	E.	24·0	25·3	Stormy.
8	M.	22·11	23·6	29·6, N. W.
	E.	22·11	24·2	
9	M.	22·0	22·3	30·0, W.
	E.	22·9	23·6	
10	M.	22·7	22·7	30·1, S. W.
	E.	23·1	23·7	
11	M.	22·10	23·1	30·0, S.
	E.	23·6	23·8	
12	M.	23·4	24·7	29·6, W. S. W.
	E.	23·11	24·0	
13	M.	24·1	24·1	29·6, S.
	E.	24·3	24·9	Bar. fallen.
14	M.	24·8	25·1	29·7, S.
	E.	24·8	24·5	
15	M.	25·1	25·1	29·8, S.
	E.	24·8	24·8	
16	M.	25·4	25·4	29·7, S.
	E.	24·9	24·7	
17	M.	—	—	
	E.	25·5	25·7	29·6, S.
18	M.	24·6	24·2	29·5, S. E.
	E.	25·4	25·2	
19	M.	23·10	23·10	29·1, S.
	E.	24·10	25·0	
20	M.	23·3	23·3	
	E.	24·4	25·0	Bar. fallen, 28·9.
21	M.	22·8	22·6	Bar. steady.
	E.	23·9	24·3	Gale W.
22	M.	22·3	22·5	28·9, W.
	E.	23·3	23·3	
23	M.	21·7	21·4	29·1, S.
	E.	22·8	22·7	

Date.	Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
Dec. 24	M.	21·0	20·2	Wind E.; frost.
	E.	22·1	21·3	29·4, S. E.
25	M.	20·6	19·5	29·6, N. E.
	E.	21·10	20·10	,, ,,
26	M.	20·9	19·8	30·1, E.
	E.	22·4	21·5	
27	M.	21·8	23·1	Bar. falling; gale.
	E.	23·1	23·11	S. W.; 29·4.
28	M.	23·0	23·4	29·4, S.
	E.	24·5	24·4	
29	M.	24·9	24·7	29·5, S.
	E.	25·10	27·0	Bar. falling.
30	M.	25·10	26·9	,,
	E.	26·11	27·7	Bar. 29·0, S.
31	M.	27·5	29·6	,, 29·0, S. W.
	E.	27·10	29·0	Bar. falling; gale, S. W.
1877.				
Jan. 1	M.	—	—	
	E.	28·4	29·7	28·8, S.
2	M.	28·3	27·8	Wind W.; Bar. rising, frost.
	E.	28·5	28·8	
3	M.	27·10	27·3	Gale, S. E.
	E.	27·11	27·6	,, ,,
4	M.	27·1	27·0	
	E.	27·0	28·9	Bar. falling; wind S. W.
5	M.	25·10	26·6	Bar. 29·0; S. W.
	E.	25·10	27·0	,, ,,
6	M.	24·4	25·0	,, ,,
	E.	24·3	25·5	Bar. 28·8; stormy.
7	M.	22·9	24·9	,, ,, ,,
	E.	22·6	25·0	High winds, S.
8	M.	21·10	23·1	Bar. 29·1; storm, S. W.
	E.	21·5	22·8	,, ,, ,,
9	M.	21·4	22·0	29·4, S. W.
	E.	21·1	21·9	
10	M.	21·5	21·6	29·9, S. E.
	E.	21·4	21·6	
11	M.	22·2	22·2	29·9, N. E.
	E.	22·0	22·2	Settled and cold.
12	M.	23·1	23·3	29·0, E.
	E.	22·9	22·6	
13	M.	23·11	24·1	Bar. falling.
	E.	23·4	24·0	Wind S.
14	M.	24·8	25·4	Signal flying; Bar. 29·0.
	E.	[illegible]	[illegible]	[illegible]

Date.	Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
Jan. 16	M.	24·10	24·11	29·9, S.
	E.	26·1	26·2	
17	M.	25·0	25·1	29·7, S.
	E.	26·1	26·1	
18	M.	24·8	24·9	Bar. falling fast.
	E.	25·9	27·0	29·5, S. W.
19	M.	24·4	24·8	Unsettled.
	E.	25·6	27·0	Gale, S. W.
20	M.	23·10	23·4	Sudden rise of Bar.
	E.	25·0	24·10	30·1, S.
21	M.	23·2	22·11	Bar. 30·3.
	E.	24·3	24·1	Wind W.
22	M.	22·2	21·10	Bar. 30·4, S.
	E.	23·2	22·7	,, ,,
23	M.	21·3	21·5	30·4, S. E.
	E.	21·10	22·1	Bar. falling.
24	M.	20·7	20·11	30·0, S.
	E.	21·1	21·0	,,
25	M.	20·7	21·5	Gale, W.
	E.	21·7	21·9	30·0, S.
26	M.	21·9	20·10	Gale, W.; Bar. 30·0.
	E.	22·10	22·7	,,
27	M.	23·4	24·2	Wind S.; Bar. falling.
	E.	24·7	24·3	Sudden rise, 30·0.
28	M.	25·4	27·6	Gale, W.; Bar. falling.
	E.	26·4	27·8	29·8, S. W.
29	M.	27·5	27·6	Wind W.; Bar. rising.
	E.	27·10	29·0	Gale, S. W.; 29·9.
30	M.	28·9	31·0	Hurricane, S.W.; Bar. 29·0.
	E.	—	—	
31	M.	28·9	28·2	Bar. sudden rise to 30·0;
	E.	29·5	29·6	[N. W.
Feb. 1	M.	28·9	29·4	Sudden fall of Bar.
	E.	29·1	29·5	29·8, S. W.
2	M.	27·9	28·0	29·7, S.
	E.	28·0	28·11	Further fall.
3	M.	26·8	27·4	Wind S. W.
	E.	26·5	28·5	29·8, S. W.
4	M.	24·9	25·8	Gale, W. N. W.
	E.	24·2	24·6	29·9, W.
5	M.	23·0	23·3	30·1, W.
	E.	22·2	23·3	
6	M.	21·0	21·0	30·0, S.
	E.	20·2	21·5	Bar. falling.
7	M.	19·9	20·3	Wind high.
	E.	19·3	19·5	30·0, W.

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
Feb. 8	M.	19·8	19·6	30·1, W.
	E.	19·8	20·0	
9	M.	20·7	20·10	30·1, S. W.
	E.	20·6	21·6	Bar. falling; wind S.W.
10	M.	21·9	22·6	Wind high.
	E.	21·10	22·2	29·8, S. W.
11	M.	23·6	24·9	Gale, S. W.
	E.	22·9	23·3	Bar. still falling.
12	M.	24·7	26·7	
	E.	23·10	24·6	29·6, S. W.
13	M.	25·7	25·11	29·6, W.
	E.	25·0	25·0	
14	M.	26·7	26·11	29·7, S.
	E.	—	—	
15	M.	25·8	25·11	29·8, S.
	E.	27·3	27·5	
16	M.	25·10	26·1	29·6, S.
	E.	27·3	27·4	
17	M.	25·7	25·8	29·8, W.
	E.	26·9	26·0	Wind W., strong.
18	M.	25·0	25·0	Bar. 30·0.
	E.	25·10	25·7	,, 29·7.
19	M.	24·1	24·5	Wind N. W.
	E.	24·8	24·11	29·9, W.
20	M.	22·11	25·6	Gale N. W.; Bar. 29·4.
	E.	23·4	25·6	,, ,,
21	M.	21·6	24·0	Stormy; Bar. rising.
	E.	21·10	20·4	Wind N. E.; Bar. 30·0.
22	M.	20·1	19·6	Wind N. E.; Bar. 30·2.
	E.	20·5	20·8	,, N. W.
23	M.	19·6	17·8	Wind N.; cold.
	E.	20·6	20·3	30·0, N. W.
24	M.	20·10	21·2	High wind, W. N. W.
	E.	22·0	22·6	Bar. falling.
25	M.	23·3	24·6	Gale, N. W.
	E.	24·5	24·7	Bar. 29·2.
26	M.	25·9	25·6	Wind N.
	E.	26·3	26·0	Frost.
27	M.	27·8	27·8	29·8, N. W.
	E.	27·11	27·7	,,
28	M.	29·2	28·8	Hard frost; wind N.
	E.	28·9	28·3	Bar. 30·1.
March 1	M.	—	—	
	E.	29·10	29·8	Wind S.; Bar. falling slowly.
2	M.	29·0	28·11	
	E.	29·9	29·8	30·1, S.

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
March 3	M.	28·0	28·0	30·1, S. W.
	E.	28·4	28·7	29·9, S.
4	M.	26·6	26·6	29·9, S.
	E.	26·3	26·4	29·9, N. W.
5	M.	24·8	24·6	
	E.	23·10	23·8	29·9, N. W.
6	M.	22·7	22·1	30·0, N. W.
	E.	21·6	21·8	Bar. falling; wind N. W.
7	M.	20·7	20·8	29·6, S.
	E.	18·11	17·7	Gale, N.; Bar. 30·0.
8	M.	18·5	17·0	Wind N., ,,
	E.	17·4	16·6	,, ,,
9	M.	18·5	18·0	,, ,,
	E.	18·2	18·0	30·1, E.
10	M.	19·8	19·6	30·1, S.
	E.	19·6	20·0	30·1, S. W.
11	M.	21·5	21·6	30·1, S.
	E.	21·3	21·3	
12	M.	23·2	24·2	30·0, S.W.; fall of ½ inch.
	E.	22·9	23·6	Strong gale.
13	M.	24·8	24·9	Rising; wind N. N. W.
	E.	24·2	24·6	Gale, N. W.
14	M.	26·0	26·4	,, 29·7.
	E.	25·3	25·0	,,
15	M.	27·2	27·2	29·6, W.
	E.	26·4	27·0	Gale, W.
16	M.	28·1	27·7	Wind N.N.W., 29·0; Bar.
	E.	—	—	[rising.
17	M.	26·10	26·2	N. N. W., 29·5.
	E.	28·1	27·3	N.
18	M.	26·6	26·6	
	E.	27·3	27·1	
19	M.	25·9	25·6	
	E.	26·3	26·0	
20	M.	24·7	24·7	Frost, 29·8.
	E.	24·8	24·10	
21	M.	23·5	23·7	N. E.; 29·4.
	E.	23·3	23·6	
22	M.	22·0	22·4	
	E.	20·3	21·7	
23	M.	20·3	20·7	S., strong; 29·3.
	E.	19·9	20·9	
24	M.	19·8	20·0	
	E.	20·8	20·8	
25	M.	21·5	20·10	S. E., gale.
	E.	22·3	22·2	,,

Date.	Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
March 26	M.	23·10	23·11	
	E.	24·10	25·3	S. Wind, strong.
27	M.	26·4	26·7	,, ,,
	E.	26·11	27·5	Stormy.
28	M.	28·1	28·3	,,
	E.	28·1	28·1	
29	M.	29·3	29·2	
	E.	28·10	28·8	
30	M.	29·5	29·2	
	E.	—	—	
31	M.	28·10	28·8	
	E.	28·10	29·1	W.
April 1	M.	27·11	27·7	N. N. W., cold.
	E.	27·4	27·6	
2	M.	26·3	26·6	W. S. W.
	E.	25·4	25·7	
3	M.	24·5	25·4	Bar. falling fast; signal fly-
	E.	23·2	23·11	Bar. 29·3. [ing; wind S.
4	M.	22·9	23·11	,, 29·0.
	E.	21·4	22·1	,, ,,
5	M.	20·8	22·3	Unsettled.
	E.	19·2	19·11	,,
6	M.	19·1	20·0	,,
	E.	17·9	18·3	,,
7	M.	18·10	18·11	
	E.	18·4	18·4	
8	M.	19·10	20·0	
	E.	19·9	20·0	
9	M.	21·5	21·6	
	E.	21·4	21·7	
10	M.	23·0	23·2	
	E.	23·0	23·4	
11	M.	24·7	24·4	
	E.	24·3	24·0	Bar rising.
12	M.	26·0	25·4	N., gusty.
	E.	25·5	25·3	
13	M.	26·10	26·6	
	E.	26·0	25·11	
14	M.	27·3	26·6	S. E., strong; Bar. 30·0.
	E.	26·6	26·0	,, ,,
15	M.	—	—	
	E.	27·7	26·7	S. E., gale; Bar. 29·8.
16	M.	26·7	26·0	S. E., ,, ,, 29·8.
	E.	26·10	25·7	E. ,, ,, ,,
17	M.	25·11	25·3	E. ,, ,,

Date.	Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
April 18	M.	24·9	24·9	
	E.	24·3	24·3	
19	M.	23·3	23·3	
	E.	22·9	22·8	
20	M.	22·1	22·3	
	E.	21·4	21·4	
21	M.	21·0	21·9	S. W.; Bar. falling.
	E.	20·6	20·9	Unsettled.
22	M.	21·2	21·4	
	E.	21·2	21·3	
23	M.	22·4	22·2	
	E.	23·0	22·11	
24	M.	24·0	23·9	
	E.	24·7	24·6	
25	M.	25·11	25·7	S. E.; 29·8.
	E.	26·2	25·10	S. E.; 29·9.
26	M.	27·2	26·7	S. E., strong; 30·0.
	E.	26·11	26·7	S. E.; 29·8.
27	M.	27·6	26·11	S. E., strong; 29·8.
	E.	27·1	26·11	,, ,, 29·9.
28	M.	27·4	27·3	
	E.	27·0	27·0	
29	M.	—	—	
	E.	27·0	26·10	
30	M.	26·8	26·5	N., frosty; 29·8.
	E.	25·8	25·9	N. W.; 30·0.

XX.—DISCUSSION OF OBSERVATIONS FOR DETERMINING THE PARALLAX OF THE PLANETARY NEBULA, 37, H. IV. MADE WITH THE SOUTH EQUATORIAL AT DUNSINK. By FRANCIS BRÜNNOW, Ph. D., F.R.A.S.

[Read, November 12, 1877.]

AT the Meeting of the British Association for the Advancement of Science, held at Edinburgh in 1871, Mr. Gill read a Paper on the "Parallax of the Planetary Nebula H. IV., 37," for which he had found a value of about two seconds. However, the number of his observations was so small, that it seemed to me advisable to make a longer series of observations of this interesting object, in order to examine whether such a large parallax really existed. The observations were commenced immediately after my return home on August 13, 1871, and were continued to August 6, 1872, with some interruptions owing to my absence from the Observatory during the months of January and February, 1872, and again during part of April and May. They are, therefore, not as numerous as I could have wished, but still are sufficient to show that the nebula has no large parallax.

The nebula appears as a somewhat elliptical disk whose major axis is about half a minute, and has in its centre a well-defined point resembling a star of the eleventh magnitude. I compared this centre in declination with a star of the tenth magnitude which precedes the nebula by 25 seconds, using exactly the same method of observing as that adopted in my former series of observations on the parallax of stars. I also used a faintly illuminated field, as I could make the bisections of these faint objects more accurately with dark wires than in a dark field with bright wires. Of course, I observed only when the atmosphere was sufficiently good to show the central point distinctly.

The observations I have obtained are as follows:—

Date.		$\Delta\delta$ expressed in rev. of the screw.	Therm.	$\Delta\delta$ in seconds.	Weight.
1871.					
August	13,	6·95815	55°·0	62″·561	
,,	15,	6·95670	54 ·0	62 ·551	
,,	25,	7·02535	50 ·5	63 ·176	
,,	27,	6·98780	52 ·0	62 ·834	
September	11,	6·99955	53 ·0	62 ·939	
,,	12,	6·98115	54 ·0	62 ·773	
,,	13,	6·98390	52 ·0	62 ·799	

Date.	Δδ expressed in rev. of the screw.	Ther.	Δδ in seconds.	Weight.
1871.				
September 23,	6·95920	40°·0	62″·603	
„ 28,	6·97930	42 ·0	62 ·779	
October 7,	6·99335	39 ·5	62 ·910	
„ 20,	6·99180	41 ·0	62 ·894	
„ 21,	7·00335	44 ·5	62 ·990	
„ 24,	6·99310	43 ·5	62 ·900	
November 5,	6·99390	37 ·0	62 ·921	
„ 22,	6·98395	38 ·5	62 ·827	
December 16,	6·99230	37 ·0	62 ·907	
„ 19,	6·99590	39 ·0	62 ·933	
„ 20,	6·97100	37 ·0	62 ·716	
1872.				
January 6,	6·97640	35 ·0	62 ·767	
March 1,	7·02915	42 ·5	63 ·227	$\frac{5}{6}$
„ 8,	7·01055	37 ·0	63 ·071	
„ 14,	7·01730	39 ·0	63 ·126	
„ 17,	7·01220	39 ·5	63 ·080	
April 3,	7·00625	35 ·0	63 ·034	
„ 12,	7·01195	40 ·0	63 ·077	
„ 13,	7·00485	41 ·0	63 ·011	
May 31,	7·00490	44 ·0	63 ·004	
June 5,	6·99815	44 ·0	62 ·943	
„ 7,	7·00085	45 ·5	62 ·966	
July 14,	6·98540	56 ·0	62 ·806	
August 2,	6·99450	52 ·0	62 ·896	
„ 6,	6·99410	53 ·0	62 ·891	

The observed apparent differences of declination must first be corrected for refraction and aberration, and reduced to a mean equinox, for which I chose as epoch the beginning of the year 1872. The effect of refraction is in this case very small, and nearly constant, as is shown by the following Table, because all the observations were made at considerable altitudes:—

Hour Angle.	Corr. for Refr.	Hour Angle.	Corr. for Refr.
0^h	+ 0″·019	4^h	+ 0″·018

The effect of aberration, nutation, and precession, is given in the following Table, which has been computed from the formulæ on page 38 of Part I.[1] :—

Date.	Reduction to Mean Δδ.	Date.	Reduction to Mean Δδ.
1871.		1872.	
August 7·7,	− 0″·050	February 9·5,	+ 0″·014
,, 17·7,	0 ·044	,, 19·5,	0 ·010
,, 27·6,	0 ·038	,, 29·4,	0 ·006
Sept. 6·6,	0 ·032	March 10·4,	+ 0 ·001
,, 16·6,	0 ·026	,, 20·4,	− 0 ·005
,, 26·5,	0 ·019	,, 30·3,	0 ·010
October 6·5,	0 ·013	April 9·3,	0 ·015
,, 16·5,	0 ·007	,, 19·3,	0 ·019
,, 26·5,	− 0 ·001	,, 29·3,	0 ·023
Nov. 5·4,	+ 0 ·005	May 9·2,	0 ·026
,, 15·4,	0 ·010	,, 19·2,	0 ·028
,, 25·4,	0 ·014	,, 29·2,	0 ·029
December 5·4,	0 ·018	June 8·1,	0 ·030
,, 15·3,	0 ·020	,, 18·1,	0 ·029
,, 25·3,	0 ·022	,, 28·1,	0 ·027
,, 35·3,	0 ·022	July 8·1,	0 ·025
1872.		,, 18·0,	0 ·022
January 0·6,	0 ·022	,, 28·0,	0 ·018
,, 10·6,	0 ·021	August 7·0,	0 ·013
,, 20·5,	0 ·020	,, 17·0,	0 ·007
,, 30·5,	0 ·018	,, 26·9,	− 0 ·001

From these Tables I found the small corrections for every observation, which are given in the first two columns of the following Table, and by applying them to the observed values of Δδ, given above, I obtained the reduced values Δδ, which are given in the last column of the following Table :—

Date.	Refr.	Red.	Sum.	Δδ.
1871.				
August 13,	+ 0″·018	− 0″·046	− 0″·028	62″·533
,, 15,	+ 0 ·018	− 0 ·045	− 0 ·027	62 ·524
,, 25,	+ 0 ·018	− 0 ·039	− 0 ·021	63 ·155
,, 27,	+ 0 ·018	− 0 ·038	− 0 ·020	62 ·814
September 11,	+ 0 ·018	− 0 ·029	− 0 ·011	62 ·928
,, 12,	+ 0 ·018	− 0 ·028	− 0 ·010	62 ·763

Date.	Refr.	Red.	Sum.	Δδ.
1871.				
September 13,	+ 0″·018	− 0″·028	− 0″·010	62″·789
,, 21,	+ 0 ·018	− 0 ·022	− 0 ·004	62 ·809
,, 23,	+ 0 ·018	− 0 ·021	− 0 ·003	62 ·600
,, 28,	+ 0 ·018	− 0 ·018	− 0 ·000	62 ·779
October 7,	+ 0 ·020	− 0 ·012	+ 0 ·008	62 ·918
,, 20,	+ 0 ·019	− 0 ·005	+ 0 ·014	62 ·908
,, 21,	+ 0 ·022	− 0 ·004	+ 0 ·018	63 ·008
,, 24,	+ 0 ·020	− 0 ·002	+ 0 ·018	62 ·918
November 5,	+ 0 ·023	+ 0 ·005	+ 0 ·028	62 ·949
,, 22,	+ 0 ·018	+ 0 ·013	+ 0 ·031	62 ·858
December 16,	+ 0 ·018	+ 0 ·020	+ 0 ·038	62 ·945
,, 19,	+ 0 ·019	+ 0 ·021	+ 0 ·040	62 ·973
,, 20,	+ 0 ·018	+ 0 ·021	+ 0 ·039	62 ·755
1872.				
January 6,	+ 0 ·023	+ 0 ·021	+ 0 ·044	62 ·811
March 1,	+ 0 ·025	+ 0 ·005	+ 0 ·030	63 ·257
,, 8,	+ 0 ·023	+ 0 ·002	+ 0 ·025	63 ·096
,, 14,	+ 0 ·024	− 0 ·001	+ 0 ·023	63 ·149
,, 17,	+ 0 ·022	− 0 ·004	+ 0 ·018	63 ·098
April 3,	+ 0 ·018	− 0 ·012	+ 0 ·006	63 ·040
,, 12,	+ 0 ·018	− 0 ·016	+ 0 ·002	63 ·079
,, 13,	+ 0 ·018	− 0 ·017	+ 0 ·001	63 ·012
May 31,	+ 0 ·018	− 0 ·030	− 0 ·012	62 ·992
June 5,	+ 0 ·018	− 0 ·030	− 0 ·012	62 ·931
,, 7,	+ 0 ·018	− 0 ·030	− 0 ·012	62 ·954
July 14,	+ 0 ·018	− 0 ·023	− 0 ·005	62 ·801
August 2,	+ 0 ·018	− 0 ·015	+ 0 ·003	62 ·899
,, 6,	+ 0 ·018	− 0 ·014	+ 0 ·004	62 ·895

If we take then $\Delta\delta_0$ as a mean value of $\Delta\delta$, $d\Delta'$ as the difference of the proper motions of the star and nebula, and denote the difference of the parallax of the nebula from that of the star by π, that of the constants of aberration for the two objects by κ every observation will give us an equation of the form:

$$0 = \Delta\delta_0 - \Delta\delta + d.\ \Delta\delta_0 + t.\ d\Delta' - b.\ R.\ \cos(\odot + B).\ \pi - b.\ \sin(\odot + B).\ \kappa.$$

The values of the constant quantities B and b were found from the well-known formulæ

$$B = 270^\circ - 19', \qquad b = 1\cdot0000,$$

Taking, then, for $\Delta\delta_0$ the value $62''{\cdot}900$, and computing the values of the coefficients of $d\Delta'$, κ, and π for every observation, I obtained the following system of equations of condition :—

Date.	Equations.				Residual Errors.
1871.					
Aug. 13,	$d.\Delta\delta_0 - 0{\cdot}382\, d\Delta'$	$- 0{\cdot}778\, \kappa$	$- 0{\cdot}637\, \pi$	$= - 0''{\cdot}367$	$- 0''{\cdot}260$
„ 15,	− 0·376	− 0·798	− 0·609	− 0 ·376	− 0 ·268
„ 25,	− 0·349	− 0·888	− 0·465	+ 0 ·255	+ 0 ·366
„ 27,	− 0·343	− 0·903	− 0·434	− 0 ·086	+ 0 ·026
Sept. 11,	− 0·303	− 0·982	− 0·191	+ 0 ·028	+ 0 ·138
„ 12,	− 0·300	− 0·985	− 0·175	− 0 ·137	− 0 ·029
„ 13,	− 0·297	− 0·988	− 0·158	− 0 ·111	− 0 ·003
„ 21,	− 0·275	− 1·000	− 0·022	− 0 ·091	+ 0 ·013
„ 23,	− 0·270	− 1·000	+ 0·013	− 0 ·300	− 0 ·198
„ 28,	− 0·256	− 0·995	+ 0·099	− 0 ·121	− 0 ·024
Oct. 7,	− 0·231	− 0·968	+ 0·250	+ 0 ·018	+ 0 ·106
„ 20,	− 0·196	− 0·888	+ 0·458	+ 0 ·008	+ 0 ·076
„ 21,	− 0·193	− 0·879	+ 0·473	+ 0 ·108	+ 0 ·175
„ 24,	− 0·185	− 0·854	+ 0·517	+ 0 ·018	+ 0 ·079
Nov. 5,	− 0·152	− 0·727	+ 0·681	+ 0 ·049	+ 0 ·089
„ 22,	− 0·106	− 0·495	+ 0·858	− 0 ·042	− 0 ·039
Dec. 16,	− 0·040	− 0·092	+ 0·980	+ 0 ·045	− 0 ·006
„ 19,	− 0·032	− 0·039	+ 0·983	+ 0 ·073	+ 0 ·014
„ 20,	− 0·029	− 0·021	+ 0·983	+ 0 ·145	− 0 ·206
1872.					
Jan. 6,	+ 0·017	+ 0·278	+ 0·945	− 0 ·089	− 0 ·185
March 1,	+ 0·069	+ 0·952	+ 0·304	+ 0 ·357	+ 0 ·190
„ 8,	+ 0·188	+ 0·982	+ 0·188	+ 0 ·196	+ 0 ·026
„ 14,	+ 0·204	+ 0·996	+ 0·086	+ 0 ·249	+ 0 ·079
„ 17,	+ 0·212	+ 0·999	+ 0·034	+ 0 ·198	+ 0 ·029
April, 3,	+ 0·259	+ 0·966	− 0·257	+ 0 ·140	− 0 ·021
„ 12,	+ 0·284	+ 0·975	− 0·404	+ 0 ·179	+ 0 ·025
„ 13,	+ 0·286	+ 0·908	− 0·420	+ 0 ·112	− 0 ·040
May 31,	+ 0·417	+ 0·325	− 0·960	+ 0 ·092	+ 0 ·008
June 5,	+ 0·431	+ 0·244	− 0·984	+ 0 ·031	− 0 ·044
„ 7,	+ 0·437	+ 0·213	− 0·992	+ 0 ·054	− 0 ·019
July 14,	+ 0·538	+ 0·393	− 0·935	− 0 ·099	− 0 ·116
Aug. 2,	− 0·590	− 0·659	− 0·763	− 0 ·001	+ 0 ·002
„ 6,	− 0·601	− 0·708	− 0·716	− 0 ·005	+ 0 ·001

thus the following final equations for determining the unknown quantities:—

$$
\begin{array}{rllllll}
+\ 33{\cdot}0000\ d.\Delta\delta_0 & +\ 0{\cdot}3172\ \kappa & -\ \ 8{\cdot}2603\ d.\Delta' & -\ \ 1{\cdot}2703\,\pi & = +\ 0''{\cdot}2400 \\
+\ \ 0{\cdot}3172\ \ \ ,, & +\ 3{\cdot}1428\ ,, & +\ \ 4{\cdot}6399\ \ ,, & -\ \ 2{\cdot}5263\ ,, & = +\ 0\ {\cdot}7179 \\
-\ \ 8{\cdot}2603\ \ \ ,, & +\ 4{\cdot}6399\ ,, & +\ 20{\cdot}5923\ \ ,, & +\ \ 0{\cdot}1074\ ,, & = +\ 2\ {\cdot}4580 \\
-\ \ 1{\cdot}2703\ \ \ ,, & -\ 2{\cdot}5263\ ,, & +\ \ 0{\cdot}1074\ \ ,, & +\ 12{\cdot}4156\ ,, & = +\ 0\ {\cdot}3016.
\end{array}
$$

The solution of these equations gives the following values:—

$$
\begin{aligned}
d.\Delta\delta_0 &= +\ 0''{\cdot}036 \\
d\Delta' &= +\ 0\ {\cdot}0978 \\
\kappa &= +\ 0\ {\cdot}112 \\
\pi &= +\ 0\ {\cdot}047.
\end{aligned}
$$

The errors which remain in the equations of condition after the substitution of these values are given in the last column of the preceding Table.

The squares of the errors are thereby reduced from $0''{\cdot}899$ to $0{\cdot}532$, which gives for the probable error of one observation the value $\pm\ 0''{\cdot}09$, and for the probable errors of the quantities above:—

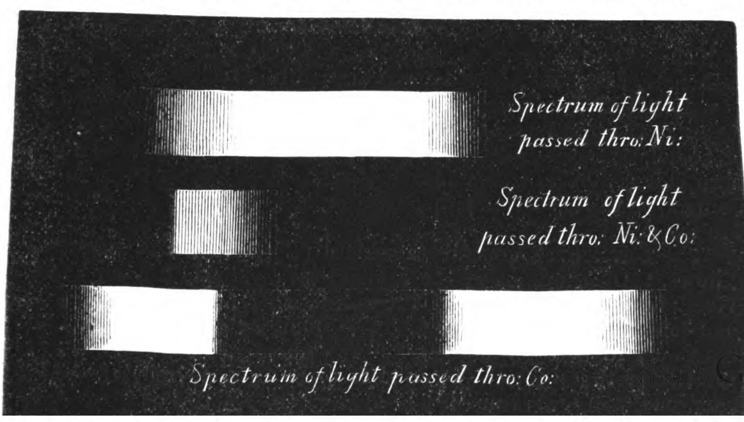
$$
\begin{array}{rl}
(d.\Delta\delta_0)\ \ldots\ldots & \pm\ 0''{\cdot}018 \\
d\Delta'\ \ldots\ldots & \pm\ 0\ {\cdot}0759 \\
\kappa\ \ldots\ldots & \pm\ 0\ {\cdot}029 \\
\pi\ \ldots\ldots & \pm\ 0\ {\cdot}030.
\end{array}
$$

XXI.—On the Colour Relations and Colorimetric Estimation of Nickel and Cobalt. By Thomas Bayley, Associate R. C. Sc. I.

[Read, November 12, 1877.]

The fact will have been observed by chemists that solutions of nickel and cobalt salts are so far complementary in colour that, when they are mixed together, the resulting liquid, if moderately dilute, is hardly to be distinguished from pure water. I conceived this fact might be made the basis of a method for estimating nickel and cobalt, and, therefore, undertook the following experiments.

A large hollow prism, filled with a moderately strong solution of a nickel or cobalt salt, was placed immediately in front of the slit of the spectroscope, and the thickness of the liquid traversed by the light was regulated by moving the prism until the eye could most clearly determine the dark absorption band caused by the metal in solution. On referring to the accompanying diagram, which shows the absorption spectra of the two metals, it will be seen that cobalt and nickel are almost exactly complementary in their relations to light. The black band of cobalt is well defined at the edges, especially at the end nearest to the red, while the absorption bands of nickel are not so sharply defined, but fade away at each end. If the spectra were exactly complementary, on superimposing the nickel spectrum upon the cobalt spectrum, the dark part on the one would exactly cover the light part on the other. This, however, though nearly the case, is not exactly so, for the light band in the nickel spectrum overlaps the dark cobalt band at the end nearest to the red, although with diminished brilliancy. Consequently, when we employ a mixture of nickel and cobalt salts in solution, we do not get a uniformly dark



lution obtained by mixing strong solutions of nickel and cobalt is not grey, but reddish brown in colour.

Having so far demonstrated the complementary character of the two metals, I next endeavoured to find in what proportions they must be mixed in order to neutralize each other. For this purpose a tall glass cylinder (150 c. c. capacity), in which ammonia is estimated by Nessler's method, was employed. Dilute standard solutions of pure nickel and cobalt having been carefully prepared, a measured quantity of cobalt solution was placed in the cylinder, and the nickel added from a burette, until the neutral point was reached. It is difficult by this method to distinguish the exact point of neutrality, but easy to determine that the colour coefficient of nickel with regard to cobalt lies between 3·1 and 3·2. That is to say, if a quantity of cobalt in solution be mixed with a solution containing 3·1 times its weight of nickel, the cobalt colour will slightly predominate in the mixture, which will have a reddish tinge; while, if a solution containing 3·2 times its weight of nickel be added, the nickel colour will be slightly in excess, and the solution will have an olive green tinge. It is only with dilute solutions containing not more than about 2·5 grams of the metals per litre, that it is possible to determine the coefficient with this accuracy.

I now sought for some method of indicating more exactly the neutral point. After several attempts it was found that the addition of ammonium carbonate to the solution of the two metals affords a means of determining whether the slightest excess of either metal is present.

If we take 25 c. c. of solution containing ·03125 gram of cobalt, and add to this 39·25 c. c. of solution containing ·098125 gram of nickel, the resulting liquid appears perfectly colourless. If we now dilute the mixed solutions to 100 c. c. and transfer 25 c. c. of that solution, containing ·0078125 gram of cobalt, and ·02453125 gram of nickel, to a tall glass jar, add 25 c. c. of the solution of ammonium carbonate, described hereafter, and then dilute to 150 c. c., the result is a liquid of deep purple colour. If we repeat this experiment, using in the first instance ·03125 gram of cobalt, and ·099375 gram of nickel, the colour of the 150 c. c. is not purple, but of a distinct blue colour. The ammonium carbonate for this purpose must be neutral, as the excess of either base or acid destroys the delicacy of the reaction.

The solution of neutral carbonate $(NH_4)_2CO_3$ was prepared as follows. A few ounces of the commercial carbonate having been dissolved in water, 10 c. c. of the solution were neutralized by standard solution of sulphuric acid. The quantity of NH_3 in the 10 c. c. was found to be ·085 gramme. The quantity of CO_2 in an equal quantity of the solution was found to be in two experiments ·348 gram, and ·350 gram (mean ·349 gram): the amount of CO_2 required to form the neutral carbonate with ·085 gram of NH_3 being ·110, it

tralize this, 18 grams of ammonia were required to be added to a litre of the commercial carbonate solution. This was furnished by 61·7 c. c. of ammonia solution (of sp. gr. ·880).

I next endeavoured to determine whether the nature of the salt of nickel or cobalt has any effect on the reaction. For this purpose the following solutions were prepared:—

$Co\,Cl_2$	1 c. c. =	·00125	grm. Co.
$Ni\,Cl_2$	1 c. c. =	·0025	grm. Ni.
$Ni(NO_3)_2$	1 c. c. =	·0025	grm. Ni.
$Ni\,SO_4$	1 c. c. =	·0025	grm. Ni.
$Co\,(NO_3)_2$	1 c. c. =	·00125	grm. Co.
$Co\,SO_4$	1 c. c. =	·00125	grm. Co.

The method of proceeding was as follows:—In each of five cylinders 25 c. c. of the standard solution of cobaltous chloride were placed; to the first cylinder 39 c. c. of the solution of nickelous chloride were added; to the second cylinder 39·25 c. c., and so on; 40 c. c. of nickelous chloride being added to the fifth cylinder. Each cylinder was then made up to 100 c. c., and 25 c. c. out of each 100 c. c., were placed in a second series of cylinders. To each of the second series neutral ammonium carbonate (25 c. c.) was added, and then sufficient water to make 150 c. c. The results are expressed in the following Table:—

Cylinder.	Co used.	Ni used.	Colour.	Ratio of Ni to Co.
(1)	·03125 grm.	·09750 grm.	purple.	3·12
(2)	·03125 ,,	·098125 ,,	slightly purple.	3·14
(3)	·03125 ,,	·098750 ,,	between 2 & 4.	3·16
(4)	·03125 ,,	·099375 ,,	slightly blue.	3·18
(5)	·03125 ,,	·10000 ,,	blue.	3·20

In two experiments, using in the first solutions of $Co\,Cl_2$ and $Ni\,SO_4$, and in the second solutions of $Co\,Cl_2$ and $Ni\,(NO_3)_2$, I obtained exactly the same results, so that the foregoing Table expresses the results of these experiments. Subsequently experiments were made with the same quantities of the metals in the following combinations, $Co\,(NO_3)_2$ with $Ni\,SO_4$, $Ni\,(NO_3)_2$ and $Ni\,Cl_2$ $Co\,SO_4$ with $Ni\,(NO_3)_2$, $Ni\,SO_4$ and $Ni\,Cl_2$.

The results of these latter experiments were exactly the same as those of the first experiments, so that the Table does equally well to express them also.

absorbing oxygen from the air to form the double compounds of cobalt and ammonia. A small quantity of a sulphite destroys the reaction, as it changes the tint to a deep brown. Thiosulphates and some other reducing agents do not act in this way.

These experiments lead to the conclusion that the colour coefficient of nickel with regard to cobalt is 3·16, in all cases, or, in other words, that the tint of nickel and cobalt solutions is independent of the acid radical in combination with the metals, and depends only upon the metal in solution. It is evident that nickel and cobalt may be estimated by means of this reaction. As an example of its application to this purpose, I give the following account of the manner in which small quantities of nickel may be estimated.

The nickel must be dissolved in an acid, and the solution diluted to any convenient quantity, *e. g.*, 50 or 100 cubic centimetres. Into each of three cylinders ·0078125 grm. of Co as $Co\,Cl_2$ is placed. This amount of cobalt is afforded by 6·25 c. c. of the standard $Co\,Cl_2$ solution. Calling the cylinders No. 1, No. 2, and No. 3, we place in No. 1, ·024531 grm. of nickel in solution, and in No. 3, ·0248458 grm. To the three cylinders we then add 25 c. c. of the standard ammonium carbonate. Cylinder No. 2, which contains only cobalt solution and ammonium carbonate, is then made up nearly to 150 c. c., and No. 1 and No. 3 are filled up to that quantity. Cylinder No. 1 has then a purple tinge, while cylinder No. 3 has a blue tinge. By adding from a burette the solution whose strength we wish to determine to No. 2, until its tint is intermediate between No. 1 and No. 3, we make with great accuracy the required determination. In all cases the cylinders should be held, whilst under comparison, with their lower extremities at some inches distance above a sheet of white paper. Three experiments, that by no means reached the highest limit of accuracy, gave the following results :—

Ni in solution.		Ni found.
·02469 grm.	(1)	·02425
	(2)	·02475
	(3)	·02500
		·02466 = mean.

It is evident that a similar plan of estimating cobalt would be still more accurate on account of the higher colour efficiency of that metal.

The partially opaque brown solution obtained by mixing *strong* solutions of nickel and cobalt might, I think, be used for making standards for the purposes of colorimetrical analysis. For instance, the brown solution mixed with a few drops of potassic bichromate cannot be distinguished from Nesslerised ammonia. Probably the tests used to compare the solutions of steel in Eggertz's process for the estimation

XXII.—ON SCHUTZENBERGER'S PROCESS FOR THE VOLUMETRIC ESTIMATION OF OXYGEN IN WATER. By CHRISTOPHER CLARKE HUTCHINSON, Royal Exhibitioner, Royal College of Science.

[Read, December 10, 1877.]

IN judging of the character of a water for domestic uses, one of the most important points to be ascertained is, the question of its pollution by sewage and other deleterious matters.

The determination of this pollution, its extent and nature, is at present rather unsettled. It is, however, believed by many chemists that a contamination, such as referred to, will exercise an effect upon the gaseous bodies held in solution in a water. It is the opinion of many, that the relative quantity of oxygen present in a water affords the key to its deterioration by organic matter; because it is unlikely that a large quantity of oxygen can be held in solution by a water containing oxidizable matter. Waters which contain their normal proportion of oxygen, in relation to their other gaseous constituents, would be regarded as free from sewage and decaying matter; a diminution in the quantity of oxygen would indicate a corresponding increase in the amount of injurious matter present.

The late Dr. Miller's analyses of the gases present in the water of the Thames, at various points, clearly proved that as the amount of sewage *increased*, the amount of carbonic acid increased, and the amount of oxygen *decreased*.

The Rivers' Pollution Commissioners state in their sixth Report that the proportion of oxygen in water is deprived of much importance, since it has been discovered that deep well waters, which cannot contain putrescent organic matter, contain little or no dissolved oxygen. The absence of oxygen in deep well waters may, however, be owing to its having oxidized and destroyed the organic matter the water previously contained, during its percolation through the strata.

In the presence of this conflicting testimony, I was induced to undertake an investigation, in the hope of throwing some light upon this important question—whether or not the amount of oxygen present is, or is not, an indication of the freedom of a water from injurious organic bodies.

In commencing the inquiry I was desirous of employing some accurate, and yet rapid, method, for the estimation of the oxygen present; for although the gasometric operations by Bunsen's method leave nothing to be desired in point of accuracy, yet on account of their somewhat tedious nature some other plan, if even slightly less accurate, but at the same time more rapid, would be desirable.

Such a method as this I thought might be afforded by the process

oxygenated liquids.[1] As the estimation is made without the removal of the oxygen by boiling, and in the condition in which it exists in the water, such a plan would seem to be more desirable than its expulsion from the liquid, together with the other gases held in solution, and their subsequent determination.

I now proceed to give the results I have obtained by means of this volumetric process.

Briefly described, the method consists in adding a known volume of the water under experiment to a solution which is capable of being oxidized (accompanied by a change of colour due to such oxidation) by the oxygen held in solution. The extent to which this has occurred is then determined, by the addition of a powerful reducing agent, which, acting upon the coloured compound so formed, reduces it to its former condition—the amount necessary being, of course, indicated by the reverse change of colour to that which occurred in the first instance. This last solution being standardized in terms of the oxygen it is capable of taking up, from the amount used in the experiment we arrive at the volume of oxygen contained in the volume of water taken.

The re-agents used I will now describe, with the method, and proportions for their preparation I found most advantageous.

The reducing agent used is sodium hyposulphite—not the commonly so-called "hyposulphite," but the sodium salt of the acid H_2SO_2; its formula as given by Schutzenberger is $NaHSO_2$. I prepared this as follows:—A concentrated solution of caustic soda ($NaHO$), specific gravity 1·4, was taken; sulphurous anhydride (SO_2) was passed through it, until the liquid was thoroughly saturated, and smelt strongly of the gas. The yellow liquid (which was kept cool during the process of saturation by immersion in cold water) is sodium bisulphite ($NaHSO_3$); it increased slightly in bulk, and was reduced to the specific gravity of about 1·34. 100 grammes (75 cub. cents.) of this solution was then briskly agitated in a flask with 6 grammes of powdered zinc, air being excluded; an elevation of temperature occurred, the bisulphite being converted partly into the hyposulphite, together with the formation of sodium sulphite and zincic sulphite, according to the following equation:

$$3\,NaHSO_3 + Zn = NaHSO_2 + Na_2SO_3 + ZnSO_3 + H_2O.$$

After agitation for about five minutes, the liquid was allowed to cool; 400 cub. cents. of water recently boiled were added; 35 cub. cents. of milk of lime, containing 200 grammes of CaO per litre, were also added, and the mixture allowed to stand until clear, when it was decanted off into well-stoppered bottles, and kept in the dark.

renders the solution less absorbent of free oxygen, although it acts very rapidly upon dissolved oxygen. Before use this was further diluted with three times its bulk of distilled water, recently boiled.

The liquid recommended by which the change of colour detects the completion of the process is either carmine indigo (sulphindigotate of soda, $C_8 H_4 Na NOSO_3$), or Coupier's aniline blue. 10 grammes of the carmine indigo are recommended to be dissolved in one litre of water, the product being kept in well-stoppered bottles also in the dark.

An ammoniacal solution of pure copper sulphate is also recommended to be made, containing 4·46 grammes (or, more correctly, 4·471 grammes) of the crystallized salt per litre. This is to be used for the standardization of the above two solutions.

Since the reducing agent is so sensitive to the presence of oxygen, it is necessary to make the estimations in an atmosphere of pure hydrogen. To ensure the purity of the hydrogen, I passed it through a solution of nitrate of silver, in addition to the sulphuric acid, and the tube containing pieces of caustic potash.

We begin by finding the volume relation between the indigo and hyposulphite. The burettes of the apparatus are filled, one with indigo carmine solution, the other with hyposulphite; a rapid current of hydrogen is passed through the apparatus, a small quantity of warm distilled water added, and this coloured by the addition of a small quantity of indigo. We now add cautiously the hyposulphite; the blue solution turns first green, and finally to a clear yellow tint. If the whole of the air has been expelled from the apparatus, the yellow tint will remain unchanged; the slightest trace of oxygen causes the surface of the liquid to become blue. A known volume of indigo (25 cub. cents.) is now added, and the hyposulphite solution again run in until the yellow tint appears, indicative of the reduction of the whole of the indigo. The colour change is exceedingly sharp, one drop being sufficient to change the colour from green to yellow. If the solution be acid, the blue colour changes first to red, and finally the yellow tint appears.

We next require to find the reducing power of the hyposulphite in terms of oxygen, finding from this the amount of oxygen any volume of the indigo will yield. This being a stable solution, the hyposulphite (being liable to change) can be readily standardized at any future time.

Two methods can be used, by which this reducing power can be found:

First. By finding the quantity necessary to reduce the ammonia copper solution, *i.e.*, the amount which brings the blue solution to a colourless state, by the reduction of the cupric to cuprous oxide, 10 cub. cents. of this solution yields 1 cub. cent. of oxygen (0°C. 760 m.m.s. pres.) to the reducer. 25 cub. cents. are operated on in a smaller apparatus, similar to the one used for the water estima-

finite, and difficult, even to the practised eye, to detect, that the exact point cannot be determined with any degree of certainty.

The second method consists in obtaining a pure water saturated with air, and then finding the quantity of hyposulphite capable of abstracting the whole of its oxygen.

This water is obtained by agitating in a large flask about one litre of distilled water with free access of air; the agitation is continued for about a quarter of an hour. To find the amount of oxygen in a given volume of the water, I made the following formula, from the consideration of the relative quantity of oxygen present in the air, and its coefficient of absorption in water:

$$v = 0{\cdot}0262 \times a_{t^\circ} \times V \times \frac{P}{95},$$

in which we have

v = vol. of oxygen in cub. cents. at 0° C. and 760 m.m.s. pres.

a_{t° = coefficient of absorption of oxygen in water at temp. t° C., given by Bunsen's Tables.

V = volume of water employed, temp. t° C.

P = barometric pressure in m.m.s.

The relation between the saturated water and the hyposulphite is found in exactly the same way as the method, hereafter described, for the oxygen determination in waters. I found that, although the hyposulphite solution was about the strength recommended, the volume relation between it and the indigo, instead of being one to ten, was equal. As the indigo solution thus appeared ten times too concentrated, I further diluted it for use.

The following is an example of standardization by the above method. The apparatus was in every way regulated as described for water estimations:—

Comparison of Hyposulphite and Indigo.

Mean of five experiments gave

25 cub. cents. indigo = 7 cub. cents. hyposulphite.

Comparison of Saturated Water and Hyposulphite.

from which is found

25 cub. cents. indigo = 218·75 cub. cents. of water.

temperature of water = 12·6° C.

barometric pressure = 744 m.m.s.

We therefore have

$$v = 0{\cdot}0262 \times 0{\cdot}031024 \times 218{\cdot}75 \times \frac{744}{95} = 1{\cdot}392\,;$$

therefore

25 cub. cents. indigo = 1·392 cub. cents. oxygen.

I made determinations on different days, at different conditions of temperature and pressure. The following shows the quantity of oxygen 25 cub. cents. of indigo was calculated to yield in each case:

Temp. 12·6° C. Pressure, 744 m.m.s.	= 1·392 cub. cents.
Temp. 15·5° C. Pressure, 771 m.m.s.	= 1·448 ,, ,,
Temp. 14·75° C. Pressure, 752 m.m.s.	= 1·354 ,, ,,
Mean, ...	= 1·398.

The small amount of variation, under widely different conditions, shows this method of standardization to be a reliable one.

I now proceed to give the method for the estimation of oxygen contained in a water. Owing to the change which the hyposulphite undergoes, it is necessary that a comparison between it and the indigo should be made each day. After this has been done, and the apparatus freed from air by means of the hydrogen, 200 cub. cents. of warm water (temp. about 50° C.) are then added; 50 cub. cents. of indigo are now run in. This I usually effected in portions of about 15 cub. cents. at a time, decolourizing each portion by means of the hyposulphite, thus utilizing this step for the comparison of the two re-agents; effecting thereby a saving of time and material. The liquid in the apparatus being now brought to the yellow neutral tint, a measured volume of the water under experiment is added—75 cub. cents. I found a convenient quantity—taking care that no air is admitted at the same time. The bleached indigo will now become re-oxidised, turning from yellow to blue, in proportion to the amount of oxygen present in the water. The hyposulphite is now cautiously added, until we again arrive at the yellow tint, free from green; a single drop of the re-

another volume of the water, until the apparatus becomes inconveniently full. I usually made from four to six such experiments in each case. The temperature of the apparatus must be kept at about 50° C., by the addition of warm water at intervals; the amount of hyposulphite required becomes gradually less as the apparatus cools, giving the results too low.

To test the accuracy of the method, I took a measured volume of the same water at the time of the experiments, expelled the gases by boiling, collected this gaseous mixture, and determined its volume and composition by the usual methods of Bunsen's gasometric analysis.

The following examples are taken, to illustrate the method of analysis.

Volumetric Method.

Mean of four determinations gave

25 cub. cents. indigo = 8·21 cub. cents. hyposulphite.

This quantity of indigo we before found to yield 1·398 cub. cents. of oxygen. Therefore

8·21 cub. cents. hyposulphite = 1·398 cub. cents. of oxygen.

Mean of five determinations gave

3·55 cub. cents. hyposulphite = 75 cub. cents. of water.

From this we find the quantity of oxygen contained in 2·420 litres of water—the volume used in the gasometric method.

2·420 litres of water contain 19·505 cub. cents. of oxygen.

Gasometric Method.

Volume used, ... 2·420 litres.
Temperature of water, . . . 13° C.

	Volume.	Temperature in o° C.	Pressure in m. m. s.	Column of Mercury above that in trough, in m. m. s.	Corrected Volume at 0° C. and 760 m. m. s. pres.
Total vol. of Gas evolved, .	302·56	13·9	737	268·8	237·719
After absorption of CO_2, .	316·149	14·9	745	229·2	193·959

Percentage Volume Composition.

Carbonic acid, ...	18·408
Oxygen, ...	31·091
Nitrogen, ...	50·500
Total, ...	99·999

Absolute Volume Composition in Cub. Cents.

Carbonic acid, ...	10·238
Oxygen, ...	17·294
Nitrogen, ...	28·087
Total, ...	55·619

	Cub. Cents.
Volume of oxygen by Volumetric method,	19·505
,, ,, ,, Gasometric ,,	17·294
Excess given by Volumetric method,	2·211

Other samples from the same source were also experimented upon, the results being variable.

Water of a different character to this last was also experimented upon, with the following result:—

Volumetric Method.

Mean of three determinations gave

25 cub. cents. indigo = 7·25 cub. cents. hyposulphite;

therefore

7·25 cub. cents. hyposulphite = 1·398 cub. cents. oxygen.

Mean of four determinations gave

3·42 cub. cents. hyposulphite = 75 cub. cents. water.

From this we find

Gasometric Method.

Volume used, ... 2·420 litres.
Temperature of water, . . . 11° C.

	Volume.	Temperature in 0° C.	Pressure in m.m.s.	Column of Mercury above that in trough, in m.m.s.	Corrected Volume at 0° C. and 760 m.m.s. pres.
Total vol. of Gas evolved, .	612·73	8·4	736·5	211·8	403·95
Gas used, ...	369·04	8·4	736·5	211·8	243·294
After absorption of CO_2, .	240·16	8·8	729·5	327·5	123·063
After admission of H, . .	364·97	8·8	729·5	187·5	253·313
After explosion, ...	261·2	8·7	729·5	296	141·584

Percentage Composition.

Carbonic acid, ... 49·418
Oxygen, ... 15·308
Nitrogen, ... 35·274

Total, ... 100·000

Absolute Volume Composition in Cub. Cents.

Carbonic acid, ... 46·715
Oxygen, ... 14·471
Nitrogen, ... 33·343

Total, ... 94·529

Volume of oxygen by Volumetric method, 12·486
,, ,, ,, Gasometric ,, , 14·471

Difference, ... 1·985

In this case the Volumetric method shows a *less* volume of oxygen

large quantity of carbonic acid present; for, as Schutzenberger points out, when an acid is present in appreciable quantity, even such a weak acid as carbonic acid, the results given are invariably too low; hence this method would not be applicable, with any degree of accuracy, to waters in which a large quantity of carbonic acid is present.

I made numerous determinations, from which the two foregoing examples are selected; but none of them showed any trustworthy results; in some cases the volume of oxygen obtained being in excess, and in others less than that obtained by the Gasometric method.

The variability of the results led me to inquire into the source of these discrepancies, and how they might be avoided.

Noticing that a change of colour in the yellow neutral tint seemed to occur to a greater extent than it should do on the addition of recently boiled distilled water, I made the following experiments.

Distilled water was boiled in a flask fitted with a cork and exit valve so as to avoid contact with air, for over four hours. The apparatus was prepared as usual with indigo and hyposulphite, the temperature being kept at 50° C. The boiled water, which was kept in well-stoppered bottles, was then added in successive portions of 75 cub. cents. at a temperature of 55° C. On each addition a blue colouration was produced in the yellow neutral liquid, just as if oxygen had been absorbed by the reduced indigo. The amount of colour change was determined as usual by the addition of hyposulphite. The mean of five experiments showed that 2·9 cub. cents. were necessary to bring back the yellow tint. This quantity was found to be equivalent to 3·86 cub. cents. of indigo, or 0·201 cub. cents. of oxygen.

Unwilling to think that this was due to oxygen which had been left unexpelled by ebullition, I boiled recently-distilled water in long-necked flasks, fitted with corks and exit valves, for over five hours. The apparatus was prepared as usual, but in this case water at 100° C. was used, and the body of the apparatus immersed in water kept at 100° C. Portions of 75 cub. cents. of water were removed from the flasks whilst in a state of ebullition, and introduced into the apparatus; each addition caused a change of colour from yellow to blue. The mean of five experiments showed that 1·25 cub. cents. of hyposulphite was necessary to destroy the colour.

1·25 cub. cents. hyposulphite = 1·66 cub. cents. indigo = 0·08 cub. cents. of oxygen.

After boiling for over six hours, the water was allowed to cool, out of contact with the air, and in withdrawing portions from it coal gas was aspirated in, instead of air, so as to avoid as far as possible contact with oxygen.

The same experiments were tried at the ordinary temperature (16·75° C.), and the same volume of water (75 cub. cents.) used. The mean of four experiments gave the colour change equivalent to 1·3 cub. cents. of hyposulphite = 1·56 cub. cents. of indigo, or 0·087 cub. cents. of oxygen.

cooling the boiled water previous to its addition, and immersing the apparatus in a bath cooled by a mixture of ice and salt. The results in this case were variable, the introduction of 75 cub. cents. of water requiring from 0·9 to 2·4 of the hyposulphite. I found this to be due to the length of time the apparatus was allowed to stand in the bath, after the introduction of the water. The longer the time, the less the quantity of the re-agent required to destroy the blue tint produced. To make certain that such a change did occur, I brought the liquid to the yellow tint, and then added a few drops of indigo, so as to produce a distinct green colour. On allowing the apparatus to stand in the bath, this gradually disappeared. I tried this several times, adding variable quantities of indigo in excess; but in all cases (within certain limits), when allowed to stand in the cold water, the green colour was gradually replaced by the yellow tint, just as if a quantity of hyposulphite had been added.

I attempted to remove these errors by a modification in the method of procedure.

The burette used for the indigo was replaced by a larger one (100 cub. cents. capacity). After placing in the apparatus a quantity of indigo solution, expelling the air, and bringing to the neutral point as usual, a known excess of the hyposulphite was added. Saturated water, as before described, was then added from the large burette, so as to oxidize the excess of hyposulphite, and just tinge the liquid green. From the volume required, by using the formula before given, the volume of oxygen contained in this can be found; hence the equivalence of the excess of hyposulphite in terms of oxygen. The same operation is performed with the water under experiment acting upon the same excess of hyposulphite. The relation between the volume used and that of the saturated water gives the amount of oxygen in the liquid. Any errors resulting from change in the solution would thus be eliminated, and the calculations simplified. On trying this method, I did not find the results any more satisfactory than the original method, although performed with the greatest care: they gave quantities in excess of that given by the Gasometric method. Thus, in 2·420 litres of water,

	Cub. Cents.
Volumetric modification gave, ...	15·133
Gasometric method, ...	12·650
Excess, ...	2·483

Although this Volumetric method possesses the great merit of exceeding rapidity, yet the many precautions necessary to be taken greatly detracts from the value and reliability of the results. It seems to be better suited for the determination of oxygen in small rather than in large quantities of a liquid, such as are desirable in water estimations.

accurate methods. The process adopted by Schutzenberger for checking the results appears to have been, submitting the liquid to the action of the mercury pump for fifteen or twenty minutes. I do not think this is sufficient, for, in expelling the mixed gases from a water by boiling, I have found that traces of gas are given off even after a considerable period.

One great drawback is the considerable amount of change the hyposulphite solution undergoes, even when excluded from the air and kept in the dark. The following give the volume ratios between it and the indigo, as taken on different days, showing the extent of this change:—

Oct. 23rd.—25	cub.	cents.	indigo	=	7	cub.	cents.	hyposulphite.
,, 25th.—25	,,	,,	,,	=	7·84	,,	,,	,,
,, 27th.—25	,,	,,	,,	=	9·8	,,	,,	,,
Nov. 1st.—25	,,	,,	,,	=	13	,,	,,	,,
,, 6th.—25	,,	,,	,,	=	20·75	,,	,,	,,

These investigations were carried out in the Chemical Laboratories of the Royal College of Science, under the supervision of Professor Galloway.

XXIII.—Further Researches on the supposed Substitution of Zinc for Magnesium in Minerals.[1] By Edward T. Hardman, F.C.S., &c., Geological Survey of Ireland.

[Read, February 25, 1878.]

Some time ago, during the analysis of chalk from the county Tyrone, I noticed that the specimens examined contained traces of zinc, and I also found that metal in small quantity in the overlying basalts. It subsequently occurred to me that, owing to its marked relations in physical and chemical characters to magnesium, zinc might be expected to occur in rocks or minerals containing compounds of the latter metal. Accordingly, I made some analyses of such magnesium minerals as I had at hand, and the results, which fully equalled my expectations, were laid before this Academy, and printed in the *Proceedings* for 1874. Those analyses comprised some eight or ten rocks or minerals characterised by magnesian compounds. Since then, in the intervals of other chemical research, I have continued this investigation, and in nearly every instance I have obtained small quantities of zinc combined in these magnesian rocks or minerals, and also in a few cases in minerals of the metals belonging to the same isomorphous groups as zinc and magnesium—for instance, in iron pyrites, and in limestone, in which there was little or no magnesia. I give below a list of twenty different specimens from various places, in all of which zinc is unmistakeably present, and often in very appreciable quantity.

Method of Analysis.—In all but one or two cases the analysis was twofold. First, an examination with the blowpipe was made, and then if zinc was indicated, a complete analysis in the wet way. In many instances the blowpipe results were so strongly marked, and so unmistakeably showed the presence of zinc, that a wet analysis was really superfluous. But to put the matter beyond all question, it was performed on a sufficiently large quantity of the rock or mineral.

For details as to the analytical methods adopted, I shall only refer to my former Papers on this subject, where they are given fully. There is one point worth mentioning, however, in this connexion. It appears to be usually the impression that the only reliable blowpipe tests for zinc are the white incrustation, and the green colour imparted by nitrate of cobalt; and that it is too volatile to be reduced to the metallic state on charcoal. Such appears to be the idea on which are based the directions for its detection, in many books on Chemical Analysis, or special works on the Blowpipe, but it is an erroneous

[1] See "Analysis of Chalk, County Tyrone, with Note on the Occurrence of Zinc therein," *Journal Royal Geological Society of Ireland*, vol. iii., p. 159. Also *Geological Magazine*, vol. x., p. 434; and "On a supposed Substitution of Zinc for Magnesium

one, for with care the metal is easily reducible. With less than half a grain of mineral, containing a mere trace of zinc, fused on one of Griffin's reduction pastiles, I have obtained sufficient of the metal to apply the most characteristic wet tests, and such as could leave no doubt as to the nature of it; while with large capsules, and a properly managed reducing flame, the feat is perfectly easy with larger quantities.

The following list gives the principal specimens in which I have found zinc:—

(1). *Talc Schist* from the sea shore, Mullaghglass, county Galway,[2] containing large, well-defined hornblende crystals. The blowpipe analysis gave strong indications of zinc. This was confirmed by a wet analysis, which showed the presence of zinc in appreciable quantity. Small quantities of copper, silver, lead, and nickel were also present.

(2). *Hornblende.*—The crystals from the above also contained zinc.

(3). *Dark-green Serpentine* from N. slope of Croagh Patrick Mountain, county Mayo, contains considerable traces of zinc; also copper, and a small quantity of nickel, quite enough for estimation. This fact deserves particular notice, since it is the only serpentine in this country, as far as I am aware, in which nickel has yet been observed. Doubtless it is of not unfrequent occurrence in such rocks, but Dana's lists of analysis only mention a few localities, most of which are American.[3] It might be expected also to occur in magnesian rocks, its compounds being isomorphous with the corresponding ones of magnesium and zinc; and, in fact, I have often met with it in such rocks, but never in such large quantity as in this specimen.

(4). *Flesh-coloured Dolomite* from the carboniferous limestone of Ballyfoyle, near Kilkenny. The blowpipe showed zinc to be present, which was confirmed fully by a wet analysis. Small quantities of copper and lead were also present.

(5). *Dolomite* from Ballyfoyle, similar to above. Presence of zinc shown by blowpipe and wet analysis. In both these in small quantity for magnesian rocks.

(6). *Dolomite* from Clara, near Kilkenny, similar to the above; extremely friable, contains crystals of calcspar; blowpipe examination proved the presence of both zinc and lead. Two wet analyses confirmed this, and showed the zinc to exist in estimatable quantity.

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[2] For this and other Galway and Mayo specimens I am indebted to my colleague Mr. G. H. Kinahan, M. R. I. A. For several others, to my colleagues Mr. Nolan, M. R. I. A., and Mr. Henry.

[3] Since writing this I find it has been noticed in the black serpentine of the Lizard. See Rev. T. G. Bonney, M. A., and W. H. Hudleston, Esq., M. A., "On the Serpentine and Associated Rocks of the Lizard District," *Journal Geological Society of London*, 1877, p. 925. Mr. Kinahan informs me that nickeliferous

(7). *Very compact Crystalline Magnesian Limestone* from Tawnagh, Toormakeady, county Mayo. Associated with upper Silurian rocks and bedded igneous rocks. The blowpipe and subsequent wet analysis showed the presence of zinc in small quantity.

(8). *Hornblende Schist* from Inish-gloria Island, Belmullet, county Mayo, gave small traces of zinc.

(9). *Hornblende Rock* from Annagh Head, Belmullet. Blowpipe examination proved this to contain zinc in very appreciable quantity, confirmed by subsequent wet analysis. A little copper present.

(10). *Very pure Talc* from county Galway. The blowpipe showed considerable traces of zinc, and some of lead. Zinc very distinct.

(11). *Black Mica* from a vein in the summit of Liss-oughter, county Galway. The blowpipe gave the usual indications of zinc *very distinctly*. Quite a number of spangles of zinc were reduced. Wet analysis confirmed its presence. Traces of copper and lead were also observed.

(12). *Orthoclase Felspar* from a felstone porphyry, county Mayo. The blowpipe gave faint indications of zinc. On reduction, a few tiny spangles were obtained, which gave the usual zinc reactions. The very small quantity of zinc present is thoroughly consistent with the theory of its connexion with magnesium, since orthoclase contains usually a very trifling amount of that metal.

(13). *Hornblendic Epidotic Rock* containing numerous radiated nests of *Actinolite* or *Tremolite*, from Cannaver Island, Lough Corrib. This rock is described by Mr. Kinahan as passing into serpentine rocks.[4] The *actinolite* is almost infusible, and appears to be a highly magnesian variety. With the blowpipe it gave abundant indications of zinc. The mineral reduced with carbonate of soda yielded a large quantity of spangles of metal easily soluble with evolution of hydrogen, in dilute hydrochloric acid. A wet analysis fully confirmed this. Traces of copper and lead were also observed.

(14). *A Serpentine Rock* from N. W. slope of Croagh Patrick, county Mayo. In a compact base contains crystals of hornblende, and layers of fibrous serpentine. The fibrous serpentine, reduced with carbonate of soda, gave numerous spangles of zinc, which afforded the usual zincic reactions.

(15). *Chlorite* from a granite from Limehill, near Pomeroy, county Tyrone. Traces of zinc very distinct.

(16). *A dark graphitoidal steatitic Argillite* from county Mayo. Examined with blowpipe. Indications of zinc distinct.

(17). *Very pure greenish Steatite* from county Mayo. The blowpipe analysis of this yielded a large indication of zinc and nickel; also traces of lead. This specimen contained an estimatable quantity of nickel; and in order to be certain of the presence of zinc, which was rendered

difficult by the presence of the former metal, no less than four distinct wet analyses from different portions of the mineral were made. In all of these both nickel and zinc were present, the former somewhat abundantly.

(18). *Talc Rock* from Crohy Head, county Donegal. From Geological Survey Collection. A white or cream-coloured rock. The blowpipe examination proved in this the presence of zinc, together with small traces of copper and lead. A proof experiment with another portion of the mineral, boiled in strong hydrochloric acid, showed the zinc to be present in appreciable quantity.

(19). *Iron Pyrites.* The last mineral contains numerous small crystals of iron pyrites. These, examined in the usual way, yielded zinc. As I have already remarked, ferrous iron belongs to the magnesium group.

(20). *Actinolite Rock* from Cannaver Island, Lough Corrib. Similar to No. 13. Blowpipe analysis proved this to contain zinc in the same quantity as in No. 13.

(21). *Serpentine* from Liss-oughter, county Galway. With the blowpipe a remarkably distinct indication of zinc. The mineral, reduced with carbonate of soda, yielded quite enough metal for identification. Besides zinc, nickel is also present in some quantity, and there are traces of silver and tin.

What I wish to urge upon your attention, as the result of these investigations, is the almost invariable occurrence of zinc in the minerals examined. I have already shown that the presence of zinc as an accessory component of minerals has been almost entirely neglected—in fact it is only mentioned where it occurs in considerable quantity, as in Franklinite or Automolite; and so uncommon is it looked on as an accessory, that the only augite in which its presence had been recorded before I had commenced this research was dignified with a special name—Jeffersonite.[5]

When a metal not usually occurring in rocks in any large quantity is recorded, it is usually because it exceptionally occurs so abundantly that its presence cannot well be overlooked; and it is only in such cases that zinc has been hitherto observed. It appears, however, that, like many other substances, it only requires to be sought after; and that its presence is not simply accidental, but the result of the invariable chemical laws of affinity and isomorphism; and I submit that zinc is as much to be regarded as an almost constant associate of the magnesium group as indium and osmium with platinum; niobium with tantalum; rhuthenium and rhodium with palladium, and so on.

In all the instances I have noted in this and my former Paper, the quantity of zinc is small; but this again is really in favour of my view. Had the metal occurred in large quantity in portions of the

rock, we should be entitled to consider its presence accidental; but its occurrence in small amount, and its being generally diffused in the rock or mineral, proves it to be truly a constituent.

A lode or thick deposit of zinc ore would be an accidental deposit; but it is from the infinitesimal quantities of this metal disseminated throughout rocks that workable accumulations are derived. As Bischof remarks, the minimum of a mineral in rocks becomes the maximum in lodes; and, although the small traces of zinc in the specimens given above may appear insignificant, it must be remembered that a knowledge of the fact of the diffusion of minute quantities of the metallic compounds through rocks leads to a correct notion of the formation of mineral veins, as otherwise we should be compelled to regard them as exotic productions, derived from unknown sources.

XXIV.—ON THE NEGATIVE PEDAL OF A CENTRAL CONIC. By JOHN C. MALET, M. A.

[Read, February 25, 1878.]

ABSTRACT.

HAVING in some preliminary investigations proved a certain property of circular cubic curves which I require for the direct object of my Paper, I then investigate directly the principal properties of the first negative pedal of a central conic from any point. Many of these properties I show are also true for a more general class of curves, viz.: unicursal sextics with six cusps: thus for any such curve the following properties are true:—

(1). The six cusps lie on a conic.
(2). The six cuspidal tangents touch a conic.
(3). The eight tangents at the four double points touch a conic.
(4). The six points of contact of the three double tangents lie on a conic.

I prove, however, many less general properties of the curve I consider, which I believe are worth noticing—for example:—

"If we take the first negative pedal of a central conic from any point on either axis, then the six tangents to the curve from the cusps, but distinct from the cuspidal tangents, all touch the same conic."

Again:—

"The sixteen tangents at the eight double points of the negative pedals, with respect to the origin of the conics

$$ax^2 + by^2 + 2gx + 2fy + c = 0,$$

and

$$bx^2 + ay^2 + 2gx + 2fy - c = 0,$$

all touch the same conic."

The last part of my Paper is occupied with the consideration of a curve which is the locus of the centre of a variable circle, which cuts orthogonally a given circle and touches a given curve. From the equation of this locus I prove that we may at once deduce the equations of the following curves:—

(1). The negative pedal of the given curve.
(2). The parallel of the given curve.
(3). The negative pedal of the parallel of the given curve.
(4). The locus of the centre of a variable circle which touches the curve and a fixed circle.

I conclude by showing that we can form the equations of the

XXV.—On the Extraction of Iodine and Bromine from Kelp. By Robert Galloway, F. C. S., Professor of Chemistry in the Royal College of Science for Ireland.

[Read, April 8, 1878.]

Having had, some time ago, facilities for becoming completely acquainted with the manufacturing processes followed for the extraction of iodine, bromine, and the potash salts from kelp, I devoted a considerable portion of time to the study of this branch of manufacturing industry. It is one of the manufactures which ought to flourish in Ireland, owing to the large quantity of the raw material (sea-weed) which can be obtained in this country. I am sorry to have to state that there is now no kelp factory in Ireland; the only buyers of Irish kelp at the present time are the Scotch manufacturers.

The description in works on Chemistry, of the processes followed for the extraction of the kelp products, are very meagre in a manufacturing point of view, especially as regards the extraction of the two most valuable substances, iodine and bromine, and these two substances are the most difficult to extract with manufacturing success. The descriptions state that such and such processes are followed; but important details are altogether omitted, as, for instance, the conditions most suitable for carrying out the processes successfully, and the different precautions which ought to be observed.

Iodine was at one time a monopoly. The iodine manufacturers combined together not to sell this substance under a certain price; which, like almost all other monopolies, had the effect of impeding rather than of promoting improvement in this branch of manufacture. The monopoly exists, I believe, no longer: new sources of supply of the substances I have termed kelp products—iodine from the mother liquors obtained in refining the nitrate of soda in Peru, bromine and potassic chloride from the salt beds in Prussia—have not only extinguished it, but have also rendered necessary the adoption of superior and more economical methods in the extraction of these substances from kelp, for the continuance of kelp being employed as a raw material.

Many methods have been proposed for the extraction of the two metalloids, iodine and bromine, from the ash of sea-weed; but the only one, as far as I am aware, which has been followed in the United Kingdom, at least up to a very recent period, is the one ascribed to Wollaston. By this method they are set free from the metals with which they are combined by the addition of sulphuric acid and manganese peroxide to the mother liquor which remains after the extraction (of course as far as it is practicable) of potassic sulphate and chloride, and what are termed the kelp salts, which are a mixture of sodic sulphate, carbonate, and chloride.

The sulphuric acid is added for a twofold purpose: a portion is

the decomposition of the hyposulphites, has completely deposited, the clear liquid is drawn off into the iodine still, and the manganese peroxide is then added to it.

When this process first came into operation, bromine had not been discovered in the ash of sea-weed; even the late Dr. Anderson, in his well-known and often quoted analyses of the ash of sea-weed, does not give it as a constituent. New analytical investigations of the ash of the various sea plants are wanted; the plants ought to be carefully freed, before incineration, from all adhering salt water, so that the quantities of chlorine, bromine, and iodine they naturally contain might be correctly ascertained. The investigation would lead, most probably, to the discovery that there are, properly speaking, *bromine* as well as iodine producing plants.

The three metalloids are each liberated from their metallic combinations by the manganese peroxide and sulphuric acid, but owing to their different degrees of affinity for metals—chlorine having the strongest, and iodine the weakest affinity—the latter is the first set free; but it requires the greatest care and attention to prevent some portion of the other two from being set free at the same time. If this occurs, they enter into union with one another, forming volatile compounds which affect the eyes, and have a very pungent odour. The liberation of the bromine or chlorine, or both, during the extraction of the iodine may occur, for instance, from the manganese oxide becoming unequally diffused in the liquid; they will also be liberated if the temperature of the liquid becomes too high; and it appears to me highly probable that the influence of *mass* will also cause their liberation, especially when the quantity of iodine becomes, by volatilization, much decreased in quantity. That they are liberated to some extent during the distillation of the iodine is at once perceived by those who visit the still during the distillation, and who are acquainted with the properties of these compounds. I may here observe that the still-man judges whether at least an undue proportion of the other two are volatilizing by the colour of the vapour; if it is of a brownish or whitish colour he is aware he is losing iodine. When the distillation is finished, and the still head removed, the vapour which escapes from the still has always a violet colour, and some iodine always remains in the liquid; for if the distillation were continued until all the iodine had volatilized, there would be evolved along with it in the last stages one or both of the other metalloids in somewhat large proportions; and consequently there would be a loss instead of a gain in iodine. These are some of the imperfections and difficulties of Wollaston's process.

The extraction of bromine follows the extraction of iodine, the same process being adopted, and similar precautions have to be observed.

It is evident such a process is unsuitable for the extraction of

it contains a large quantity of potash salts and all the sulphuric acid employed in the extraction; the money value of which is estimated to be nearly one-half of the whole cost for extracting all the products from the kelp.

Chlorine is the agent, out of the many proposed as substitutes for the manganese oxide and sulphuric acid, which I would recommend, but under conditions somewhat different from those I have seen described; this difference in the conditions would render the process more exact, and better results in every respect would be obtained. The kelp solution I would render neutral by the addition of sulphuric acid before adding an aqueous solution of chlorine; and as I have found by investigation that the kelp solution contains clay, and as this substance tends to render the solution viscid and unfavourable for crystallization, I would, before evaporating to obtain the last crop of potassic chloride, nearly neutralize the liquid so as to get rid of it. Although a little more acid would be consumed than if it were all added in the ulterior stage, the disadvantage would be more than compensated by the larger crop of crystals of potassic chloride which would be obtained, and the greater concentration of the liquid. After the extraction of the last crop of potassic chloride, I would neutralize the liquid exactly, and then place it in a graduated vessel; I would then add to a small measured portion of it some bisulphide of carbon, and finally some chlorine water from a graduated vessel, until the violet colour just disappeared. This is a process frequently employed for the estimation of iodine, and occupies only a minute or two. Having ascertained the exact quantity of chlorine water which decolourizes the iodine—that is, converts it into pentachloride of iodine—it would only remain to add to the larger measured quantity of the liquid containing the iodine one-sixth of the relative quantity of the chlorine water which was required on the smaller scale. The small portion of iodine which would remain dissolved in the liquid, owing to its slight solubility in water, I would remove either by bisulphide of carbon or benzol. After the removal of the iodine, I would treat the liquid with chlorine water, with similar precautions for the removal of the bromine; but as the compound of chlorine and bromine is a monochloride, one-half, and not one-sixth, as in the case of the iodine, of the relative quantity of chlorine water would have to be added to the larger measured portion of the liquid.

If, in any case, it should be found desirable not to precipitate the entire portion of the iodine and bromine with chlorine water, on account of rendering the liquid too dilute, a portion might first be precipitated by chlorine gas, and the remainder by means of chlorine water in the way I have described.

XXVI.—On a New Chemical Test for Carbolic Acid, and its Useful Applications. By Edmund W. Davy, A. M., M. D., Professor of Forensic Medicine, Royal College of Surgeons, Ireland.

[Read, May 13, 1878.]

I had the honour, a short time ago, of bringing under the notice of the Academy, and of publishing in these *Proceedings*,[1] a new and exceedingly delicate chemical test for alcohol which I had at the time discovered; and I pointed out some practical applications which might be made of that test.

I subsequently directed attention to some further useful objects which may be attained by the employment of that alcoholic test, which latter have appeared in the *London Pharmaceutical Journal* for last year. I have recently discovered that the reagent which I employed for the detection of alcohol in the test referred to, viz., a solution of molybdic acid or molybdic anhydride in strong sulphuric acid, is a very delicate test likewise for carbolic, or as it is otherwise termed, phenic acid, a substance which is now one of considerable industrial importance, admitting as it does of so many useful applications, and one for which it is desirable to have a ready and at the same time a delicate test, for the detection of its presence under different circumstances. I have observed that when a drop or two of a dilute aqueous solution of carbolic acid is brought in contact with a few drops of the molybdic solution stated, there is immediately produced a light-yellow or yellowish-brown tint, which, passing to a maroon or reddish-brown, soon develops a beautiful purple colouration, which latter remains without further change for a considerable time. I should here observe that the application of a gentle heat will hasten the development of the purple reaction, though it will take place, but more slowly, at the ordinary temperature; and it is the production of this purple under the circumstances stated that constitutes the test for carbolic acid. The molybdic solution which I have chiefly used for this purpose is similar to the one I have employed for the detection of alcohol, and is made by dissolving, with the assistance of a gentle heat, one part of molybdic acid in ten parts by weight of pure and concentrated sulphuric acid. But the exact amount of molybdic acid dissolved appears to be a matter of indifference, as I have used other proportions with success, and in some recent experiments I found that a solution where there was only one part of molybdic acid in a hundred parts of sulphuric acid acted very well.

The mode of using this reagent is simply to add three or four drops of it to one or two of the liquid under examination, placed on any

lain capsule, furnished with a handle, which will admit of the application of heat when it may be desirable to hasten the reaction by that agent.

This test is one of great delicacy, for I have found that one small drop of an aqueous solution of carbolic acid, containing a thousandth part of its weight of that acid, and only absolutely about the one-seventy-thousandth part of a grain, when mixed with three or four drops of the molybdic solution, produced immediately the yellowish-brown effect, which, after a few minutes, passed into a very distinct and beautiful purple colouration, and this colour remained quite perceptible on the fourth day afterwards, though it had each day become fainter from exposure to the air, and its consequent absorption of moisture. But this is not the limit of its delicacy, for I have detected by its means the carbolic acid in one drop of an aqueous solution five times more dilute, or where it contained the one-five-thousandth part of its weight of that acid, and in which there was only about the one-three-hundred-and-fifty-thousandth part of a grain present.

For the success of this test, it is necessary to attend to a few particulars, one of the most important being, that only a drop or two of the liquid under examination should be employed, for if much more be used the reagent will be diluted too much, and the characteristic reaction will not take place: for so great an effect has water on it, that even when the purple colouration is fully developed, the addition of that substance will cause either the colouration to disappear almost entirely, if the quantity of carbolic acid present be exceedingly minute, or if more abundant it first changes the purple to red, and then into a light reddish-brown, which becomes more and more faint on further dilution; but the addition of a few drops of the test solution, or even of strong sulphuric acid, again reproduces the purple, though of course fainter in its colour in proportion to the previous degree of dilution; thus showing that the mixture must be very strongly acid for the production and continuance of this purple effect. Another point to bear in mind is this, that when carbolic acid itself, and not an aqueous solution of it, is acted on by the molybdic reagent, a dark olive, quickly changing to a very deep blue, will be produced, but not the purple colouration; a cold saturated aqueous solution, however, of carbolic acid when so treated will yield the purple reaction; but even here there will be a tendency to develop the olive or blue effect, especially where the reagent employed contains a large proportion of molybdic acid; and I may observe that weaker solutions of carbolic acid give more satisfactory results, as the action appears to be too energetic when the acid itself or very strong solutions are employed.

The last precaution I wish to direct attention to, for the successful performance of the test, is this, that in applying heat to hasten the reaction, it should be limited to a gentle heat that the hand can bear

tinued for some time, the purple colouration will be destroyed and a blue produced; moreover, where organic matters are present along with the carbolic acid, many of them will likewise, when heated with the molybdic reagent to that latter temperature, or even much below it, develop a deep blue colour, which would mask more or less completely the purple effect of the carbolic acid. Consequently it is better in most cases to let the test act on the liquid at the ordinary temperature, though the reaction may be somewhat slower in developing itself.

I have made a number of comparative experiments with this test, and with the principal ones hitherto employed for the detection of carbolic acid, and I find, in point of delicacy, it seems only to be surpassed by the bromine test of Dr. Landolt, which depends on the circumstance that when an aqueous solution of bromine is brought in contact with carbolic acid, there is immediately formed the tribromophenol ($C_6H_3Br_3O$), a sparingly soluble white substance. But that test could not be successfully employed, at least immediately, in many cases, where the test just described might be still available, as for example, in the case of different organic mixtures, where the presence of the tribromophenol formed would be concealed. It possesses likewise the great advantage of being apparently not interfered with, to any extent, by the presence of organic substances which mask or prevent the reactions of many of the other tests.

As to what is the exact nature or composition of the purple compound which is formed in carrying out the test, I have not yet been able to determine, owing to the difficulty of isolating it, or of obtaining it in a condition suitable for analysis; but I am inclined to think that it is not so much an oxidation product of carbolic acid as a deoxidation one of molybdic acid, and that it is a combination of one of the oxides of molybdenum, containing perhaps more oxygen than the blue compound which is formed where the molybdic reagent acts on alcohol and on some other substances; and one circumstance amongst others which seems to support this view is this, that I have failed to obtain by the action of other oxidizing agents on carbolic acid a similar purple reaction.

Be this however as it may, I have satisfied myself that the purple compound formed in my test is a totally different substance from the red or crimson dye termed coralline, which is obtained by the united action of oxalic and sulphuric acids on carbolic acid, and is now largely used as a dyeing material; for the red colour of the latter substance is not affected by the caustic alkalies, and strong sulphuric acid changes it to a reddish yellow; whereas the purple developed in the new test is changed to green by caustic alkalies, and the purple again restored by strong sulphuric acid. I am, however, still engaged in this inquiry,

powerful poison, and many instances are now on record where it has been the cause of death, such being generally either cases of suicide, or those where it has been accidentally taken by mistake for some other substance; as its odour and taste would render its administration, at least to an adult, by the assassin for the criminal destruction of life, a matter of some difficulty. The occurrence, however, from time to time of the cases referred to obviously renders it very desirable to be able readily to detect the presence of carbolic acid where it has been so used, either in the articles of food, drink, or medicine which have been taken, or in the ejecta or contents of the stomach; and this test affords a very easy and ready means of so doing, and of confirming the indications of other tests. According to my observations it will detect the presence of carbolic acid in different complex organic mixtures, even where the odour of that substance may be quite imperceptible; and I may observe, that the test of odour has hitherto been regarded as the most delicate for carbolic acid in such cases.

The great advantage this test possesses, especially for such applications, is this, that it does not appear to be much affected or interfered with, as already stated, by the presence of a number of organic substances which are likely to be present in such cases. Thus, as regards different articles of food—I have readily detected, by means of this test, the presence of carbolic acid when a small quantity of its aqueous solution had been added to the following articles, viz.: tea and coffee mixed with sugar and milk, porter,[2] ale, wine, a solution of Liebig's extract of meat, and albumen; also where it had been added to blood, olive oil, gum, and soap—the very diverse substances in the articles mentioned not preventing the indications of the test.

It will also afford a ready means of detecting the elimination of carbolic acid in the urine, when that substance has been taken internally, for the compounds present in human urine naturally do not appear to affect to any extent this test. I may also observe, that with it I was at once able to detect the presence of carbolic acid naturally occurring in the urine of a cow, without any previous treatment of that secretion, and thus confirm the correctness of the statement as to the occurrence of that acid as a normal substance in the urinary secretion of that animal. This ready means of discovering carbolic acid in different animal fluids where it may exist will render this test useful to the physiologist and physician.

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[2] As alcohol acts on the molybdic solution producing an intense blue colouration, the presence of that substance, at least in any quantity, would mask more or less completely the reaction of carbolic acid. In examining, therefore, alcoholic liquors for that acid, it is better to submit them to distillation to separate the alcohol, and then to test the later portions of the distillate or the residue for carbolic acid; or what answers even still better in such cases is, to render the liquid

Another useful application of this test is, that it affords a very ready means of distinguishing creasote from carbolic acid, which is a matter of some commercial importance, much of what is sold as creasote being, as is well known to chemists and those in the drug trade, little else than carbolic acid; for these two substances, though obtained from different sources—true creasote being procured from the distillation of wood tar, whilst carbolic acid is got from that of coal tar—and though they differ likewise from each other in chemical composition, still so closely resemble each other in several of their properties, that the cheaper substance, impure carbolic acid, is in whole or in part frequently sold to the public for the dearer article creasote. If, however, we take a drop or two of each, and agitate them well with about a quarter of a fluid ounce of distilled water, and, having filtered the liquid, test a drop or two with the molybdic solution as already described, we will get in the case of pure creasote only a brown or reddish-brown reaction, which on standing or warming slightly becomes fainter, passing to a light-yellowish brown: whereas in the case of carbolic acid the brown passing to a maroon soon develops a more or less intense purple colour. This treatment will be sufficient to distinguish creasote from carbolic acid, and also to detect the presence of that acid in creasote, where it occurs in considerable proportion; for if, on the addition of the molybdic test solution, the mixture, instead of fading away to a light-yellowish brown on standing a short time, or on gently heating, passes to a reddish brown or to a maroon, it is an indication that carbolic acid is present. But I have found that the following very simple proceeding gave more satisfactory results, especially where small quantities of carbolic acid had been added to a large proportion of creasote. From five to ten drops of the liquid under examination are taken, and agitated briskly with about half an ounce of distilled water for a few minutes, so as to dissolve out the carbolic acid; the mixture is then filtered, and the filtrate is put into a little flask furnished with a close-fitting cork, through which passes a small glass tube about ten or twelve inches long, and bent above the cork at a little more than a right angle. The contents of the flask are then heated, and, when the liquid boils, the first portions which distil over will be found to present a more or less turbid appearance as they pass down the tube, from their containing minute globules of creasote; and a drop or two having been collected and tested with the molybdic reagent will give only the brown reaction of creasote: but by continuing the boiling, that substance will be more or less completely expelled, and then it will be found that a drop or two of the later portions of the liquid which distil over will give the purple reaction of carbolic acid. I may here observe that as it is only a drop or two of the distillate which is required each time for testing, it is not necessary to use any condensing arrangement, for the vapour passing through the tube itself is cooled sufficiently to furnish the small quantity required for each

later portions of the distillation, a very small Liebig's condenser, in which the delivery tube can be inserted, will be found the most convenient arrangement to employ. In this way, by distillation, I was enabled to detect the presence of carbolic acid in creasote, where I had mixed only one part of the former with a hundred parts of the latter, which would be more than sufficiently delicate for any case likely to occur in commerce; for where such adulteration was practised, it is probable that a much larger proportion of carbolic acid would be used, to render the fraud sufficiently remunerative. In the same way, I have readily succeeded in detecting the presence of carbolic acid in oil of cloves, where I had purposely added a small proportion of that acid, as it is stated that this very objectionable fraud is occasionally practised, of adulterating the essential oil of cloves with carbolic acid.

The few applications that I have referred to are, I should trust, sufficient to indicate the practical utility of this test; which, being at the same time so simple and easily performed, will, I have no doubt, be found useful for the objects stated, as well as for others to which it may be applied.

XXVII.—ON HULLITE, A HITHERTO UNDESCRIBED MINERAL; A HYDROUS SILICATE OF PECULIAR COMPOSITION, FROM CARNMONEY HILL, CO. ANTRIM, WITH ANALYSIS. By EDWARD T. HARDMAN, F. C. S., H. M. Geological Survey. With NOTES ON THE MICROSCOPICAL APPEARANCES, by Professor HULL, F. R. S.

[Read, June 24, 1878.]

PART I.

HAPPENING to visit Carnmoney Hill, near Belfast, during the Meeting of the British Association in 1874, I was much struck with the abundance in the basalt of a mineral which I had never before noticed in any of the basalts of the north of Ireland, and which I had reason to believe then, and still consider to be, somewhat new to Irish mineralogists, in so far that its composition and physical characters have not yet been described. It may have been observed before, but there is no description, at all agreeing with its characteristics, published.

The basalt in which this mineral occurs forms the old neck of a Miocene volcano. It is massively columnar, the columnar structure being, however, horizontal, not vertical, as is usually seen; but in all respects similar to what may be observed in large dykes or other masses of intrusive basalt. The rock itself is a rather coarse-grained dolerite; extremely vesicular and amygdaloidal, possesses a very high density, and is magnetic, affecting the needle very strongly—zeolites are not abundant, but the cavities are filled, or in some places only coated, with a peculiar black mineral which is the subject of the present notice.

In some cases this mineral entirely fills up the cavities, and throughout the rock it appears in great profusion; but in many places where the amygdaloids are only partially coated with it, the remaining space is filled with calcite—and occasionally apparently arragonite—for sometimes the crystals have a radiated structure which resembles that of a zeolite.

The black mineral from this locality has, I believe, never been hitherto described or analysed. On examining the maps of the Geological Survey I find the basalt is noted by the late Mr. Du Noyer as "black basalt, highly crystalline; cellular cavities lined with pitchstone," for which he evidently mistook this mineral. And in the Geological Survey collections in the Museum of the College of Science, Dublin, specimens from this place are labelled "Vesicular basalt, with obsidian." However, the peculiar softness of the mineral precludes this idea at once. There are two minerals to which it bears a distant resemblance. In physical characters it somewhat agrees

that mineral by Macculloch and Forchammer, which give very extraordinary results. The presence of so called chlorophæite has been noted by Portlock[1] as occurring in the basalt of Down Hill (p. 227); Magilligan—abundantly in several beds exposed in the section there (p. 152–3), and at Carrick-a-rede, where the mineral imparts a porphyritic appearance to the rock (also at Craigahulliar, p. 154), and he mentions localities as Crosseagh and south Ballylagan where the trap, wanting the imbedded chlorophæite, has cavities occasionally lined with obsidian (p. 155)—this he mentions as occurring at the Giants' Causeway. Now it seems improbable that a highly acidic mineral such as obsidian would be found in basalt; and I am inclined to suppose that Portlock, as Mr. Du Noyer did afterwards, mistook the Carnmoney Hill mineral for obsidian.

Whether this Carnmoney Hill mineral is the same as that which Portlock calls chlorophæite I cannot say, as I have not seen specimens from the localities he names. But it is not at all clear that Portlock's so called chlorophæite is that of Macculloch, since analyses of it are wanting. If it be the same mineral as that I have examined, the composition is entirely different.

In chemical composition the mineral approaches more nearly to delessite. However, there are still very important differences, as will be seen on comparison. Delessite contains considerably less silica, more alumina, and more protoxides—lime especially being abundant. Again, the physical characters do not agree,—delessite is harder; its gravity is nearly $\frac{2}{3}$ more, its colour and streak different,—so that on the whole we must regard this mineral as a new one, although possibly belonging to the ferrugenous chlorite group.

Method of Analysis.—Separation of the mineral. This is so important a point that it may be well to devote a few lines to the description of the manner adopted. Although the mineral occurs most abundantly in very small nodules, it was found to be a most tedious process to extract sufficient of it even for a qualitative analysis. One method was to crush the rock—extract as much of the matrix as possible by means of a strong magnet, the small particles of magnetite, or perhaps native iron disseminated throughout it, rendering this possible, and collecting the mineral bit by bit with a forceps from the felspar and augite which remained behind. This, however, promised to be an endless proceeding—but I fortunately at the time happened to meet with a notice of the use of Sonstadt's solution for that purpose;[2] this I tried, and it succeeded so admirably that, although I have already noticed the result elsewhere,[3] a short description of the process may not be out of place here, as it is a matter that cannot be too well known to mineralogists.

[1] *Geological Report on Londonderry, Antrim, &c.*

Sonstadt's solution is a solution of mercuric iodide (or red iodide) in potassic iodide—the liquid being concentrated by adding, alternately, the mercuric and the potassic iodides until no more of either is taken up. Carefully proceeding in this way, a clear liquid can be obtained, having a specific gravity of a little over 3·00, according to Sonstadt and Church. It is clear that any mineral of less specific gravity than 3· floats on such a liquid, while any of higher gravity of course will sink; by diluting the liquid we can obtain a range of solutions capable of separating any minerals between 1·0 and 3·0 s. g. The Carnmoney mineral being of low specific gravity, a solution of about 2·0 was sufficient. The rock being crushed up and sifted, to get rid of small dust, which would have rendered the result less palpable, was thrown into a dish filled with the solution. Everything but the new mineral sank to the bottom. The latter was then skimmed off, and immediately washed with distilled water to which a little potassic iodide had been added, to dissolve any red iodide which would otherwise be thrown down, and finally washed with distilled water. When a sufficient quantity of the mineral had been thus collected it was again treated in the same way, and thus was cleared of a few particles of augite, &c., which had been caught up in the first floatation.

In this way about 3 grammes of the mineral were obtained, perfectly free from admixture, and quite sufficient to yield exact analytical results.

The analysis was conducted in the usual way, by the fusion of the powdered mineral with the alkaline carbonates. Although it appears to be nearly altogether decomposed by boiling (when powdered) in strong hydrochloric acid, the fusion process seems to be the most complete method, and is the shortest in the end; because, if boiling with acid is depended on, the insoluble residue will be found almost invariably to contain undecomposed silicates, giving an excess in the amount of silica.

The ferrous iron was determined according to Early's method, namely, by decomposing the mineral with hydrofluoric acid, and estimating the ferrous iron as quickly as possible by means of a standard solution of bichromate of potassium.

As it was not easy to obtain enough of the mineral to enable its specific gravity to be taken in the ordinary way, its gravity was determined in a somewhat novel way. It floats on, and is hardly affected, even after some months, by strong sulphuric acid of the usual density, viz., 1·84. Dilute sulphuric acid, of the density of the mineral, was prepared, and the specific gravity determined by means of a delicate hydrometer;[1] the density by this means was found to be only 1·76, so

[1] Sonstadt's solution might have been used, but sulphuric acid was found to be more convenient at the time.

The analysis was performed by me in the Laboratory of the Royal College of

that the mineral is the lightest silicate known of, almost. This is very remarkable in a mineral containing such a very large percentage of iron, the peroxide amounting to 20·720 per cent.

Physical characters.—Colour, velvet black. Hardness, about 2, brittle; lustre, waxy but dull; streak, olive brown; Blow-pipe with difficulty fusible at edges to a black glass, which in some specimens is magnetic. Very slightly affected by strong HCl or H_2SO_4 when in the mass, but decomposed by the former when boiled in it in powder. Occurs filling amygdaloidal cavities in the basalt of Carnmoney Hill, near Belfast; Shane's Castle, Lough Neagh[1]; &c.

Chemical Composition and Formula.

I shall compare my analysis of this mineral with analysis of delessite and chlorophæite.

	Hullite.	Delessite.[2]	Chlorophæite.[3]
Silica . . . (SiO_2), .	39·437	31·07	33·30
Alumina . . (Al_2O_3), .	10·350	15·47	—
Peroxide of iron . (Fe_2O_3), .	20·720	17·54	—
Protoxide of iron . (FeO), .	3·699	4·07	26·70
Protoxide of manganese (MnO), .	Trace.	–	—
Lime . . . (CaO), .	4·484	19·14	—
Magnesia . . (MgO), .	7·474	0·46	—
Water . . . (H_2O), .	13·618	11·55	40·00
Carbonic acid . (CO_2), .	Trace.	–	–
	99·782	100·00	100·00
Formula	$[CaMgFe'']_3[Al'''Fe''']_4Si_6O_{21} + 7H_2O$	—	$Fe\,Si\,O_3 + 6H_2O$
Sp. gr., ...	1·76	2·89	2·02

Like other ferrugenous chlorites (as delessite), to which group this mineral appears in many respects to be allied, it is extremely difficult to express its composition by a chemical formula. In the first place, there is always some degree of alteration, which has changed the characters of the mineral; and besides, it is difficult to say whether these minerals are true silicates or combinations of silicates with aluminates. With regard to the last, it would be very difficult to decide

[1] A specimen of basalt from this locality containing very large cavities filled with this mineral is to be seen in the Museum of the College of Science, Dublin.

one way or the other in the present case, and I would prefer to content myself with calculating a formula on the supposition that that mineral is only a silicate. However, the above analysis does not give a reasonable formula in its entirety. Calculated as it stands, it gives

$$M''_3\ M'''_4\ Si_6O_{21} + 7H_2O,$$

which fails to agree with any type of silicate I know of.

If, however, we subtract one molecule of peroxide, and suppose it to exist as a hydrate, and not combined, we get

$$(M'_3\ M''_2{}'\ Si_6O_{18}) + H_6\ M'''_2o_6 + 4H_2O,$$

the first member of which is a condensed meta-silicate on the type

$$H_{12}\ Si_6O_{18}$$

which would bring it sufficiently near the type of talcose and chloritic minerals. However, the general constitution, even allowing for this, is entirely different. Then again, we may suppose the excess of peroxide, as in the above, to act the part of an acid, an aluminate, or a ferrate, which is not improbable, and we thus get a formula not unlike that which has been proposed for ripidolite, but the silicate belonging to a different condensed meta-silicic series, viz.,

$$[M''_3\ M'''_2O_6 + M'''_2H_6\ Si_6O_{18} + 4H_2O],$$

a part of the water in this case being basic, as I have but little doubt it is, acting in fact as a protoxide.

It is extremely probable that the last formula gives a fair representation of the molecular composition of this new mineral.

I should wish to draw attention to one or two remarkable points about this mineral. 1° the very large percentage of iron it contains, and the small quantity of magnesia, although it is extremely refractory before the blow-pipe; and 2° its very low specific gravity, notwithstanding the quantity of iron it contains. The last circumstance is, I think, due to the very large percentage of water.

With regard to its claims to be an original mineral, and not simply a product of alteration, I would like to point out one or two strong evidences. The mineral occurs coating or filling ordinary amygdaloidal cavities in the basalt. It is clearly a product of infiltration into these cavities, and not an alteration of a previous mineral, because the walls of the cavities are quite distinct from the mineral. Were it a product of alteration, it might be expected to merge into the rock itself, or such minerals as might be altered to such a composition, such as olivine or augite; but this is not the case, the olivine and the augite are quite

augite, felspar, and olivine may be seen to penetrate it in such a way as to leave no doubt that the Carnmoney mineral has been deposited in those spaces.[1]

Under these circumstances I consider it to be an original (but secondary) mineral, and believe it to be a new variety of the chloritic group, and a well-marked one. I therefore propose to give this Irish variety a distinguishing name.

Macculloch, in his description of the mineral chlorophæite, apologises for giving it a new name, saying that though it may afterwards turn out a variety only, its characteristics are strongly marked; and that the best chance of its obtaining future investigation will be derived by giving it a conspicuous place in the list of minerals. On the same grounds I venture to name the present mineral as a new species. Since distinctness of colour and hardness may vary in different specimens, and therefore mislead—and there is no earthly use in commemorating a single locality when the mineral may hereafter be found in hundreds of places—I submit that the best name would be that of an individual. I propose to name this species or variety Hullite, after Professor Hull; first because it has been analysed and described during his directorate of the Geological Survey of Ireland; and last, but not least, in commemoration of the valuable work he has done in the elucidation of the microscopic mineralogy of the rocks of Ireland, more especially that of the basalts.

In order to set at rest any question as to the mineral being an alteration product, Professor Hull, at my request, had some slices of the rock made, and the microscopic examination of them fully bears out my previous remarks, viz., that the mineral is perfectly distinct from, and does not merge into any part of, the basalt.

Part II.—On the Microscopical Structure of the Olivine Basalt of Carnmoney Hill, Co. Antrim. By Professor E. Hull, M. A., F. R. S.

The rock occurs as a dark crystalline mass, with columnar structure, filling the neck of an old volcanic vent of the Miocene age. (*See* Geology of the Country around Antrim, *Mem. Geol. Survey*, Sheet 21, p. 30). With the lens it is seen to consist of black glistering crystals of augite, set in a paste consisting of a light-coloured waxy felspar (plagioclase), and large and small grains of an opaque, black, dense mineral, with smooth, somewhat conchoidal, fracture, and brown streak. This unknown mineral is that to which Mr. Hardman has applied the name "Hullite," and the chemical composition of which he has determined. The olivine, though scant,

under the microscope, is scarcely to be identified without the aid of a high magnifying power.

Microscopical appearance.—Under the microscope, and with a low power (25 diameters), the slice is seen to consist of light brown augite, without crystalline form, in which are imbedded short prisms of plagioclase, imperfect crystals of olivine, and a very few grains of magnetite. But the most abundant mineral is that now for the first time described by Mr. Hardman. It is of a dark umber brown colour, almost opaque, except at the edges, and it forms not only individual masses, but permeates the whole rock, filling the interstices, and enclosing the other minerals. In one instance, where it has apparently filled in a cell in the rock, the central portion is vacant; but it often forms considerable masses. As it does not polarize, it cannot be considered as in a crystalline molecular condition; and in its distribution, and relation to the other minerals, it assumes very much the character of amorphous chlorite. Like chlorite, also, it has every appearance of being a secondary mineral, formed after the consolidation of the rock, and with a high power shows a stalagmitic or chalcedonic structure, with wavy bands.

One of the most interesting circumstances regarding this rock is the abundance of olivine in its unaltered condition. In no other instance, amongst the basalts and dolerites of Antrim which I have examined, have I found it so abundant, and in its original state olivine, as is well known, is a mineral very liable to decomposition, and generally it has been completely removed, the outer form only being preserved. In the case, however, of the basalt of Carnmoney Hill, it is as abundant and as fresh as in the lavas of Vesuvius. This can be determined by the aid of the polariscope, by means of which the crystalline grains of olivine are separated out from the augite with which it might otherwise be confounded; but under polarized light, not only may the outline of the crystalline forms be recognised, but the mineral affords (on rotating the analyzer) the well-known alternation of colours, from ruby red to sap green, characteristic of this mineral. On the other hand, the colours of the augite are blue, grey, light pink, and yellow. The crystalline forms of the olivine are only imperfectly developed. The crystals of plagioclase—probably labradorite felspar—are well and sharply defined, and seem to have crystallized out before those of augite and olivine. With the polariscope they show the usual parallel-banded structure, varying with the angle of the analyzer.

From the remarkably fresh appearance of the olivine one might infer that this rock was comparatively recent, did we not know, from physical considerations, that it must be older than the Glacial and Pliocene Periods.

XXVIII.—Further Observations on Pyrrol and its Derivatives. By Chichester A. Bell, M.B., University Dublin.

[Read, June 24, 1878].

Synthesis of Pyrrol.

Several attempts which I have made to effect the synthesis of pyrrol have not been successful. The following experiment is chiefly of interest as suggesting a process by which bases of similar constitution are likely to be obtained artificially. When vapours of diethylamine $(C_2H_5)_2$ HN, are passed through a heated tube packed with recently-ignited pumice, they experience but little change if the temperature be much below that of redness. On the other hand, a good red heat is sufficient to decompose the base into a variety of products, amongst which ethylene, free hydrogen, cyanogen, and hydrocyanic acid, are easily recognised. If the tube be of sufficient length, the current of vapour not too rapid, and the temperature that of *incipient* redness, a liquid is obtained containing, besides much diethylamine, a considerable quantity of pyrrol. The change probably consists in a direct separation of hydrogen, thus—

$$\left.\begin{array}{l} CH_3-CH_2 \\ CH_3-CH_2 \end{array}\right\rangle NH = \left.\begin{array}{c} \qquad H \\ HC=C \\ | \qquad \\ HC=C \\ \qquad H \end{array}\right\rangle NH + 3H_2$$

I have not in this way prepared any large quantity of the base, but in all cases have estimated the product by the rapidity and intensity with which the vapours issuing from the tube exhibited the fir-wood reaction, the amount of precipitate yielded by the acidified distillate with mercuric chloride, stannous chloride, etc., and by the quantity of pyrrol-red obtained by boiling the liquid in the receiver with strong hydrochloric acid.

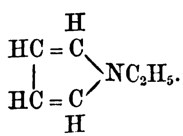
I think it not unlikely that the conversion of diethylamine into pyrrol may be effected in a more simple way.

On the so-called ethyl-pyrrol of Lubawin.

In my previous communication on this subject (these Proceedings,

viously described by Lubawin.[1] According to this chemist, when iodide of ethyl acts upon potassium-pyrrol C_4H_4NK, substitution of the group C_2H_5 for potassium takes place, a body of the composition $C_6H_9N = C_4H_4N(C_2H_5)$ being formed. This base was said to have a turpentine-like odour, to boil between 155° and 175°C., and to turn brown rapidly on exposure to air. The metal potassium acts with great vigour upon pyrrol, expelling hydrogen and producing potassium-pyrrol; but upon ethyl-pyrrol from mucate of ethylamine it has little or no action. It would be contrary to analogy to suppose that in Lubawin's base the ethyl-group does not occupy the position of the potassium in potassium-pyrrol, and it was hence difficult to resist the conclusion that the bases prepared from potassium-pyrrol and from ethylammonium mucate must be identical. On repeating Lubawin's experiment I have found this to be the case. Potassium-pyrrol is most easily prepared in a state of purity by adding to pyrrol, contained in a flask with inverted condenser through which a stream of dry hydrogen is passed, rather less than the calculated quantity of bright metallic potassium. The action is violent at first, and must be moderated by the application of cold; towards the close it must be assisted by a gentle heat. The contents of the flask are finally heated to fusion, allowed to cool, the flask broken, and the solid mass dropped into a mortar containing anhydrous ether. It is then quickly powdered, the ether (which removes unaltered pyrrol) quickly poured off, and the powder again transferred to a flask provided with an inverted condenser. It is then covered with rather more than the theoretical quantity of ethyl iodide, and the mixture boiled for a couple of hours, a chloride of calcium tube being placed in connexion with the upper end of the condenser so as to prevent ingress of moisture. Towards the close of the boiling, a not inconsiderable amount of ammonia is evolved, evidently due to secondary decompositions. On fractionally distilling the contents of the flask, a very large quantity of *ethyl-pyrrol* is obtained, boiling at 131°C., and having all the other properties of the base from ethylammonium mucate. Above 131°C. a quantity of secondary products of inconstant boiling-point comes over, the thermometer rising to 180°. It is this mixture that Lubawin evidently mistook for ethyl-pyrrol, no doubt regarding the principal product of the reaction as unaltered pyrrol, from which indeed it differs but little in odour or boiling-point. (Pyrrol boils at 133°C.)

It is thus clear that only one ethyl derivative of pyrrol is yet known, no doubt having the constitution—



[1] "Zeitschrift für Chemie," [2] v. 399.

Condensation-products of Ethyl-pyrrol.

In my former paper I mentioned that ethyl-pyrrol may be boiled for some time with strong hydrochloric acid without experiencing any change, in this respect differing from pyrrol. If the boiling is continued for a sufficiently long time, this is not the case. Even when dilute acid is used, the base gradually dissolves, forming a deep-red solution which is not rendered turbid by the addition of water. This solution contains the hydrochlorate of a new base, or perhaps salts of several new bases. The product is obtained by precipitating the acid solution with ammonia in excess. On drying the precipitate *in vacuo*, or at a gentle heat, it is obtained as an amorphous powder, which is nearly insoluble in water, but is readily taken up by alcohol or ether. Its colour varies from pale brown to black, accordingly as it has been prepared with dilute or with strong acid. Heated on the water bath it constantly loses weight, giving off a peculiar odour. Analyses showed it to be of uncertain composition, the following being the mean results:—

$$C = 68{\cdot}64, \qquad H = 8{\cdot}81, \qquad N = 9{\cdot}63.$$

This composition agrees most closely with the formula $C_{16}H_{24}N_2O_2$, which requires—

$$C = 69{\cdot}56, \qquad H = 8{\cdot}69, \qquad N = 10{\cdot}1.$$

Such a body might be formed according to the following equation:—

$$3C_6H_9N + 2H_2O = C_{16}H_{24}N_2O_2 + \overset{\text{Ethylamine.}}{C_2H_7N},$$

and, in fact, when potash has been used as a precipitant, it is easy to detect abundance of ethylamine in the filtrate. The powder melts at 165°–170°C., but not sharply. It is soluble in all acids (except nitric acid) even when dilute. On evaporating the solution in hydrochloric acid on the water-bath, the hydrochlorate remains in the form of blood-red scales, showing no trace of crystalline form. These re-dissolve easily in water. The base is precipitated from its acid solutions by minute quantities of nitric acid or nitrates, as a flocculent brown powder. Bromine or chlorine water, stannic and mercuric salts, likewise precipitate it. In its characters and composition it approaches some of the amorphous alkaloids extracted from cinchona bark.

Pyrrol-red (which, however, is entirely destitute of basic properties) is produced from pyrrol in a perfectly similar way,

$$3C_4H_5N + H_2O = C_{12}H_{14}N_2O + NH_3.$$

Carboxyl derivatives of Pyrrol.

and di-carboxyl derivatives of these pyrrols. The corresponding acids had not at that time been procured. These amides are rather stable compounds, and are very slowly attacked by mineral acids and alkalis.

If it is attempted to decompose them by prolonged boiling with strong alkaline solutions, it is impossible to prevent the decomposition of the acids as fast as formed. I have found, however, that they may be easily split up by enclosing them in sealed tubes with strong alcoholic potash, and exposing the tubes for some time to a temperature of about 120°C. They are then resolved with facility into free ammonia-base and the potash salts of the corresponding acids; thus—

Dimethyl-carbopyrrolamide. Methyl-carbopyrrolic acid.

$$C_4H_3N(CH_3)(CONHCH_3) + KHO = C_4H_3N(CH_3)COOK + NH_2CH_3.$$

Diethyl-carbopyrrolamide. Ethyl-carbopyrrolic acid.

$$C_4H_3N(C_2H_5)CONHC_2H_5 + KHO = C_4H_3N(C_2H_5)COOK + NH_2C_2H_5.$$

I have not, however, been able to obtain amyl-carbopyrrolic acid. Its amide when heated with potash yields amyl pyrrol, amylamine, and potassic carbonate.

$$C_4H_3N(C_5H_{11})CONHC_5H_{11} + 2KHO = C_4H_4N(C_5H_{11}) + K_2CO_3 + NH_2C_5H_{11}.$$

The potassium salts of these acids are obtained in the solid form by evaporating their alcoholic solutions. They are very soluble in water and alcohol. By cautiously adding to their concentrated aqueous solutions dilute hydrochloric acid in *very slight* excess, the mixture being carefully cooled from time to time, the acids are separated as flocculent precipitates which soon become crystalline. The crystals must be rapidly washed with cold water. To remove small quantities of silica (derived from the glass tubes) they must be dissolved in ammonia and again precipitated with hydrochloric acid. When thoroughly free from mineral acid they may be crystallized from water at about 90°C. (not higher), in which they are freely soluble.

Methylcarbopyrrolic acid crystallizes in needles which are very soluble in alcohol and ether. It melts at 135°C.; heated a little beyond this point, it breaks up into methyl-pyrrol and carbonic anhydride.

$$C_4H_3N(CH_3)COOH = C_4H_4N(CH_3) + CO_2.$$

It volatilizes with partial decomposition in a current of steam. Its salts are as a rule easily soluble in water: those of the alkalis and alkaline earths dissolve in alcohol. *Argentic methyl-carbopyrrolate* $C_4H_3N(CH_3)COOAg$, obtained by double decomposition, crystallizes from much boiling water in transparent prisms which deflagrate feebly when heated. ·446 grams of the finely powdered salt, mixed with sand to avoid loss by too rapid decomposition, gave on cautious ignition ·206 grams of silver = 46·19 per cent.: calculated = 46·55 per cent.

soluble in boiling water than that of the previous acid. Found, 43·89 per cent. of silver; calculated, 43·9 per cent.

In contact with boiling water, or in the cold in presence of even highly dilute mineral acids, these two acids are rapidly resolved into methyl- or ethyl-pyrrol and carbonic anhydride. Their solutions in water below its boiling point are tolerably stable so long as they are contained in smooth glass vessels; but rough surfaces (filter paper) or fine points cause rapid decomposition. They give with neutral ferric chloride a red colour.

Ethyl-dicarbopyrrolic acid.—$C_4H_2N\ (C_2H_5)\ (COOH)_2$ is obtained by the action of large excess of alcoholic potash at 130° C, upon *triethyl-dicarbopyrrolamide*, one of the decomposition products of ethylammonium mucate. The potassium salt crystallizes from alcohol in long needles. The acid is obtained from its aqueous solution by precipitation with hydrochloric acid. It appears as a sandy powder, quite insoluble in boiling water, and not decomposed by it. It is easily soluble in alcohol and ether. By crystallization from dilute alcohol it is procured in brilliant needles, which when heated do not melt, but at about 250° C. are resolved into ethyl-pyrrol and carbonic anhydride.

$$C_4H_2N(C_2H_5)\ (COOH)_2 = C_4H_4N(C_2H_5) + 2CO_2$$

Analysis gave the following results:—

	Found.	Calculated.
C	= 52·26	52·26
H	= 5·27	4·91
N	= 7·96	7·65

The nitrogen determination was a little too high, owing to the accidental employment of slightly impure soda-lime.

The salts of this acid are mostly soluble in water. The silver salt is an insoluble sandy powder. Found, 53·97 per cent. Ag: calculated for, $C_4H_2N(C_2H_5)\ (COO\ Ag)_2$ = 54·4 per cent.

The acid is very slowly decomposed in the cold by concentrated hydrochloric acid. Boiling dilute nitric acid dissolves it, but deposits it unchanged on cooling. Strong and warm nitric acid also dissolves it, but does not again deposit it on dilution.

About two per cent. of its weight of this acid may be obtained from the mucate of ethylia.

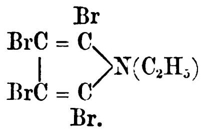
Action of Bromine upon Pyrrol Derivatives.

When bromine is added to a solution of ethyl-pyrrol in ether or chloroform, the mixture becomes dark-coloured and gives off hydro-

The insoluble solid compound formed is filtered off and repeatedly crystallized from boiling spirits of wine, in which it is sparingly soluble in the cold. It then crystallizes in brilliant colourless needles which melt at 90° C., or beneath warm spirit. They are easily decomposed above 100° C. It might have been expected that a body so poor in hydrogen as ethyl-pyrrol would have given an addition compound with bromine. But analysis shows that towards this reagent the pyrrol nucleus behaves like benzol.

Found.	Calculated for. $C_4Br_4NC_2H_5$
C = 17·3	17·51
H = 1·43	1·21
Br = 77·2	77·85
N = —	—

The compound remains apparently unchanged when digested with excess of bromine water. No doubt it has the following constitution:—



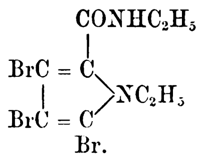
Diethylcarbopyrrolamide, $C_9H_{14}N_2O$, also does not unite directly with bromine. When bromine dissolved in chloroform is added to a chloroform solution of the amide, it is at once decolourized: but even in the cold, fumes of hydrobromic acid are given off, and, on allowing the chloroform to evaporate, a tenacious mass is left, in all probability a mixture of unchanged amide with a substitution compound.

When shaken with bromine water, diethylcarbopyrrolamide yields an insoluble substitution compound and a soluble oxidation product. To obtain the first, careful manipulation is required, since it passes into the second with the greatest ease. The amide is first dissolved by continued agitation in so much warm water that nothing separates on cooling. Bromine water is then dropped in very cautiously, the mixture being shaken after each addition. The two new compounds are produced simultaneously, the first separating in small clots, and rendering the mixture milky. On continuing the addition of bromine, a point is reached at which the milkiness suddenly disappears, and the liquid becomes transparent, while the clots adhere to the sides of the flask. This clearing marks the point at which all the amide has been acted upon, and any further quantity of bromine added is used up in oxidizing the clots. The liquid is filtered, and the solid residue is repeatedly crystallized from 60% alcohol, in which it is freely soluble

but dissolves with facility in alcohol or glacial acetic acid. It melts with partial decomposition at 120° – 121° C. Analysis gave the following numbers :—

	Found.		Calculated for. $C_9H_{11}Br_3N_2O$
C	= 26·65	. . . . . .	26·79
H	= 2·95	. . . . . .	2·73
Br	= 59·36	. . . . . .	59·55
N	= —	. . . . . .	—

It is evidently derived from the amide by the substitution of three atoms of bromine for three atoms of hydrogen. Its constitution is most probably



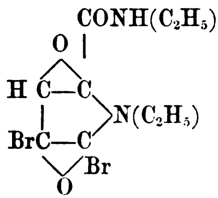
When the clear liquid from which this body has been filtered off is evaporated on the water-bath, much hydrobromic acid escapes, and a crystalline body is deposited. This must be removed before the liquid has gone quite to dryness, and it is then easily purified by crystallization from water or alcohol. The new body forms small hard transparent crystals which melt with decomposition at 197° C. It dissolves easily in all alkalis, and is reprecipitated by dilute acids. Its ammoniacal solution, when evaporated to dryness on the water-bath, leaves a residue which is not dissolved by water, and which appears to be the original body, still, however, containing a little ammonia. This is not the behaviour of a true acid. Boiling with fixed alkalis decomposes it completely, ethylamine, alkaline bromide, and other bodies not as yet investigated, being formed. Analysis leads to the formula $C_9H_{11}Br_2N_2O_3$.

	Found.		Calculated.
C	= 30·08	. . . . . .	30·42
H	= 3·31	. . . . . .	3·09
Br	= 44·87	. . . . . .	45·07
N	= 7·8	. . . . . .	7·88
O	= —	. . . . . .	—

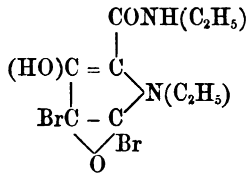
This compound is also obtained when the tribrominated diethylcarbopyrrolamide is treated with bromine water. The reaction is perhaps the following :—

$$C_9H_{11}Br_3N_2O + Br_3 + 2H_2O = C_9H_{11}Br_2N_2O_3 + 4HBr.$$

that it contains one atom of hydrogen more than is indicated by analysis, and give to it some such structure as the following :—



or



either of which would require 3·37 per cent. of hydrogen.[1] This view is quite justified by the analysis of the corresponding methyl-compound given below. The second formula would have the advantage of accounting for the property of the compound of dissolving in alkaline solutions. As I have pointed out, the ammonia compound is decomposed by simple heating on the water-bath, which would seem to point to the presence of a hydroxyl group. It is unlikely that any oxidizing action has been exerted upon either of the lateral groups, C_2H_5; for, firstly, the compound readily evolves ethylamine when heated with caustic potash, and secondly, tetrabrominated ethyl-pyrrol is scarcely attacked even when heated with bromine water.

From *dimethylcarbopyrrolamide* similar bodies may be obtained by shaking with bromine water. I have not isolated the first of these, having had only a small quantity of amide to work with: but the second or oxidized compound is obtained as easily as its ethyl-analogue, which it resembles in crystalline form, solubility, &c. It melts, however, at a higher temperature, 204° – 205° C., at the same time decomposing. I give a partial analysis of it.

Found.	Calculated for. $C_7H_8Br_2N_3O_3$
C = 25·27	25·6
H = 2·61	2·44
Br = 48·23	48·78

The study of the action of potash and of reducing agents upon these bodies will probably explain their constitution.

[*Note added in the Press.*]

[1] A more carefully prepared specimen of the body gave, on analysis, C = 30·42 and H = 3·64; agreeing well with the formula $C_9H_{12}Br_2N_2O_3$, which requires C = 30·34, H = 3·37 per cent.

XXIX.—On the Distillation Products of the Saccharates of Ammonium and Ethylammonium. By Edwin Lapper, F.C.S., L.C.P.I., and Chichester A. Bell, M.B., Univ. Dublin.

[Read, June 24, 1878.]

In a former communication,[1] one of us has shown how that by the action of heat upon the mucates of the fatty amines, a series of bodies is produced which may be regarded as substitution compounds of the base *pyrrol*, C_4H_5N, obtained by the dry distillation of ammonium mucate. Amongst these is a dicarboxyl derivative of ethyl-pyrrol, $C_4H_2N(C_2H_5)(COOH)_2$, the formation of which is of peculiar interest, since it shows that the production of the pyrrol nucleus from mucic acid is not dependent on the separation of its carboxyl groups.

In the hope of being able to throw some light upon the isomerism of mucic and saccharic acids, we have now studied the action of heat on the saccharates of ammonium and ethylammonium. It appeared to us very probable that by this action we would obtain either bodies isomeric with those from mucic acid, or totally different products; and that, in either case, we might be able to draw conclusions as to the constitution of the two acids. In one respect our expectations have not been fulfilled: nevertheless, our experiments have established an interesting difference in the deportment of the two acids, which may at some future time be of importance in determining their constitution.

Ammonium saccharate was prepared exactly according to the directions given by Liebig. The acid was purified by crystallization of its acid ammonium salt, which was then converted into the neutral salt.

The saccharate is most conveniently heated in a capacious glass retort, by means of a paraffin bath. Decomposition begins when the bath is heated to 136° C., and takes place quickly at 160° C. After some time the whole of the saccharate disappears, leaving only a slight carbonaceous residue in the retort. Ammonia and carbonic anhydride escape in large quantity, and the liquid in the receiver consists of an aqueous solution of ammonium carbonate, covered by a layer of oily liquid. The neck of the retort is covered with numerous crystals, but these consist entirely of ammonium carbonate. On careful evaporation on the water bath, the watery distillate leaves only a trace of non-volatile matter. The oily layer, after being washed, dried, and rectified, possesses all the characters, boiling-point, specific gravity and reactions, of ordinary pyrrol, its identity with which is thus satisfactorily proved. The following equation expresses the reaction—

$$C_6H_{10}O_8(NH_3)_2 = C_4H_5N + 2CO_2 + NH_3 + 4H_2O.$$

Pyrrol is obtained in almost theoretical quantity; and if ammonium saccharate could be conveniently prepared, it would undoubtedly be the best source of the base.

With this equation we may contrast the action of heat upon ammonium mucate, by which not only pyrrol, but also *carbopyrrolamide*, is formed—

$$C_6H_{10}O_8(NH_3)_2 = C_4H_4N(CONH_2) + CO_2 + 5H_2O.$$

The amide, by boiling with baryta-water, is easily converted into *carbopyrrolic acid;* and this acid when heated splits up into pyrrol and carbonic anhydride—

$$C_4H_4N(COOH) = C_4H_5N + CO_2.$$

Since ethylamine acts upon mucic acid differently from ammonia, we have also studied the action of heat upon ethylammonium saccharate.

To obtain this salt, and to avoid the tedious preparation of free saccharic acid, we took equivalent weights of acid ammonium saccharate and diethyloxamide. The first was converted into neutral salt, and to its concentrated aqueous solution, carefully freed from excess of ammonia, we added the neutral sulphate of ethylia prepared from the diethyloxamide. The mixture was evaporated to dryness *in vacuo* at a gentle heat, and the residue exhausted with absolute alcohol, which extracts only ethylammonium saccharate. After evaporating the alcohol, the salt remained as a syrupy mass, which showed little tendency to crystallize. It was therefore at once distilled.

Ethylammonium saccharate decomposes with intumescence at about 120° C., exhibiting the same appearances as the ammonia salt, except that no crystals are formed in the neck of the retort. The watery liquid which collects in the receiver contains only ethylammonium carbonate, and the oily layer consists of nearly pure ethylpyrrol in almost theoretical amount. The equation—

$$C_6H_{10}O_8(NH_2C_2H_5)_2 = C_4H_4N(C_2H_5) + 2CO_2 + NH_2C_2H_5 + 4H_2O,$$

represents the decomposition. A most careful examination failed to detect any other substance either in the distillate or in the residue. The latter was exceedingly small.

Ethylammonium mucate, on the other hand, breaks up by heat in the following ways:—

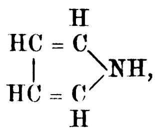
(1). $C_6H_{10}O_8(NH_2C_2H_5)_2 = C_4H_4N(C_2H_5) + 2CO_2 + NH_2C_2H_5 + 4H_2O$;

(2). $C_6H_{10}O_8(NH_2C_2H_5)_2 = C_4H_3N(C_2H_5)CONHC_2H_5 + CO_2 + 5H_2O,$

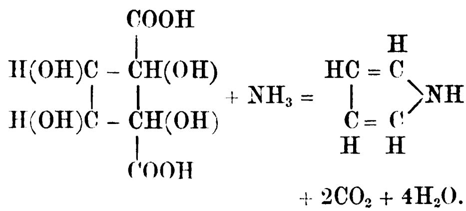
With regard to the cause of the difference in the behaviour of the two acids, but little can be said. According to all experiments hitherto published, it is extremely probable, if not absolutely certain, that the relative position of the carbon atoms is the same in both. Both are *normal* compounds; and the differences between them must be due to the positions of their hydroxyl groups. If we give to either acid (*e. g.* mucic acid) the formula

$$CO_2H - CH(OH) - CH(OH) - CH(OH) - CH(OH) - CO_2H,$$

and to pyrrol the constitution proposed by Baeyer,



the formation of the latter is easily explained—



At the same time one or both of the carboxyl groups may become amidated, and may remain with the pyrrol nucleus. In saccharic acid now we may imagine a greater number of hydroxyl groups to be joined to the carbon atoms in the neighbourhood of the carboxyl, and consequently the latter to be rendered unstable. Hence, when ammonium saccharate is distilled, it parts with both carboxyl groups, and gives pyrrol, but no carbopyrrolic acid. This explanation is reasonable, for we know that oxyacids as a rule lose CO_2 much more easily than the acids from which they are derived, and those in which the OH is near the carboxyl more easily than those in which it is remote from it. Thus, succinic acid, when heated, yields an anhydride, whilst tartaric acid (dioxysuccinic acid) decomposes into carbonic anhydride and pyroracemic acid. Again, salicylic acid separates more easily into phenol and CO_2 than either of its isomerides, para- and meta-oxybenzoic acids; whilst benzoic acid may be distilled unchanged. Many similar examples might be adduced.

Royal Irish Academy.

MINUTES OF PROCEEDINGS.

MONDAY EVENING, NOVEMBER 12, 1877.

SIR ROBERT KANE, F. R. S., President, in the Chair.

The following Papers were read :—

"On the Colour, Relations, and Colorimetric Estimation of Nickel and Cobalt." By Thomas Bayley, Esq. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

"On a Comparison of the Observed and Calculated Heights of High Water at Fleetwood, from the 8th August, 1876, to the 9th October, 1877." By Rev. James Pearson, M. A. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

"On Sculptured Fragments of Bone from the Tumuli at Slieve-na-Calleagh." By E. C. Rotherham, Esq.

"On Observations of the Parallax of the Planetary Nebula. H. IV. 37." By Dr. Brünnow. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

Donations were presented, and thanks voted to the several donors.

STATED MEETING, NOVEMBER 30, 1878.

SIR ROBERT KANE, F. R. S., President, in the Chair.

The Secretary of Council reported that the Council had taken steps towards the entertaining by the Academy of the British Association, during their meeting in Dublin, at a Conversazione; and that

the Mansion House, and had placed at the disposal of the Academy such rooms in the Mansion House as might be required for the purposes of the Conversazione.

It was Resolved—

"That the Academy approves of the steps taken by the Council towards giving a Conversazione to the British Association, and that a subscription list be opened to defray the expenses."

It was Resolved—

"That the Academy gratefully acknowledge the kindness of the Lord Mayor in placing the required rooms in the Mansion House at their disposal for the Conversazione to be given to the British Association."

By decree of the Council, Dr. Richey, Q.C., read to the Academy a return for the better management of the Cunningham Fund, in the form of a draft letter of instructions to the solicitor of the Academy.

LETTER OF INSTRUCTIONS TO ACADEMY'S SOLICITOR.

"ROYAL IRISH ACADEMY HOUSE,
"DAWSON-STREET, DUBLIN,
"1*st June*, 1876.

"SIR,

"Pursuant to authority for this purpose given to us by the Council of the Royal Irish Academy, we request that you will take the necessary steps to have a petition on behalf of the Academy presented to the Court of Chancery, for the purpose of enabling the Council to apply the surplus of the fund called The Cunningham Fund to the objects of the Institution.

"The Institution is incorporated for the promotion of Science, Polite Literature, and Antiquities. The Cunningham Fund arises from a bequest to the Academy, on trust to apply the income 'in such premiums as they should think proper for the improvement of natural knowledge and other objects of their Institution.'

"The Academy have entrusted the administration of this Fund to the Council.

"The Council is advised that this state of facts gives a legitimate ground to apply for relief under the *cy pres* jurisdiction of the Court of Chancery.

"The history of the Fund and of the endeavours of the Council, from time to time, down to 1861, to apply it to the particular purpose described, will be found at page 406 of the 7th vol. of the *Proceedings* of the Academy, herewith sent. Attention is requested to the statement, at page 417, respecting the disinclination of Members of Council to be themselves competitors, and its consequences.

"Since then, a few medals only have been awarded; and, although subjects for Prize Essays, to the amount of £100, have, within the last three years, been proposed and largely advertised, the Council have not received any Papers to which they could conscientiously award the prize.

"The result is, that the Fund now consists of the principal sum of £1600, in the Report mentioned, with accumulations of interest, amounting together to £2560 9*s.* 5*d.* of New Three per Cent. Stock.

"The Council are much pressed for funds to defray the necessary charges of printing their *Transactions* and *Proceedings*, which, though not coming directly within the language of the trust, are meritorious works, the publication of which tends to the promotion of the general objects of the Testator.

"You will, therefore, be pleased to take the necessary steps for obtaining the authority of the Court of Chancery that the Council, after providing for such premiums as may, from time to time, appear well merited and calculated to promote the particular objects of Testator, may apply the interest of the Cunningham bequest generally in aid of the objects of the Academy, viz., in promoting the study of Science, Polite Literature, and Antiquities, or otherwise as to the Court shall appear proper.

"It occurs to us that the proceedings should be under Lord Romilly's Act, and that the petition need not go into much detail.

"We are, Sir,

"Your obedient servants,

"Alexander George Richey (*per* S.F.)

"Samuel Ferguson, V. P.

"Arthur Barlow, Esq., *Solicitor*.

It was Resolved—

"That the several proceedings of Council relative to the Cunningham Fund, commencing December 12, 1875, the petition in this matter, and the draft letter of instruction be printed, and a copy thereof be sent to each and every of the Members; and that the subject-matter of said letter of instruction be taken up by the Academy at its meeting of the 14th January, 1878."

Monday Evening, December 10, 1877.

Samuel Ferguson, LL. D., Vice-President, in the Chair.

Charles Smith, Esq., Barrow-in-Furness, was elected a Member of the Academy.

The following Papers were read:—

"On Schutzenberger's Process for the Volumetric Estimation of Oxygen in Waters." By C. C. Hutchinson, Esq. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

"Observations on Double Stars." By Dr. Brünnow.

Monday Evening, January 14, 1878.

Sir Robert Kane, F. R. S., President in the Chair.

Read, the following letter from the Science and Art Department of 21st December, 1878.

"Science and Art Department,
"South Kensington, S. W.,
"21*st December*, 1877.

"Sir,

"It was stated in the letter of the Vice-President of the Committee of Council on Education, dated the 8th of February, 1876, on the subject of the formation of a Science and Art Museum in Ireland, that their Lordships earnestly desired to retain the advantage of the

dertaking, would afford; and in order to aid them in the administration of the Science and Art Museum, the Natural History Collections, and the Botanic Gardens, they propose to constitute a Board of Visitors, consisting of twelve Members—four nominated by the Lord Lieutenant, five by the Royal Dublin Society, three by the Royal Irish Academy—the Members to be appointed for a limited time, but to be re-eligible; and a President, to be elected annually by the Board; and that the duties of the Board of Visitors would be to make annual reports to the Science and Art Department, which should be laid before Parliament, on the condition, management, and requirements of the Museum, and to advise on points affecting the administration.

"Parliament has now sanctioned the building of the Science and Art Museum; and as some of the collections and departments connected with it are already in existence, and the selection of the site for the Museum, on the property which has now been vested in Government, must shortly be made, the Lords of the Committee of Council on Education are most anxious to have the benefit of the assistance of Visitors from the commencement of this important national undertaking.

"I am therefore directed to request that you will be so good as to move your Academy to nominate three gentlemen to serve on the Board for a period of five years.

"I am, Sir,

"Your obedient servant,

"NORMAN M'LEOD.

"THE PRESIDENT, ROYAL IRISH ACADEMY."

The President stated that the subject of this letter would be considered at the Meeting of the 28th inst., and the election of three Visitors of the National Museum would be then proceeded with.

After some remarks by the President on the loss the Academy had experienced by the lamented death of their late President, Dr. Stokes, the following Resolution was passed unanimously:—

"That the Royal Irish Academy, having received with deep regret the announcement of the death of Dr. Stokes, desires to place on

sent to his family, with an expression of the earnest sympathy of the Academy with their sorrow under the loss they have sustained."

Resolved—

"That as a further mark of respect to the memory of our late President, Dr. Stokes, the Academy do now adjourn."

And the Academy adjourned accordingly.

MONDAY EVENING, JANUARY 28, 1878.

SIR ROBERT KANE, F. R. S., President, in the Chair.

The Rev. J. H. Jellett, B. D.; Samuel Ferguson, LL. D., and Sir Robert Kane, F. R. S. (President), were elected Members of the Board of Visitors of the new Science and Art Museum in Ireland.

It was moved by the Secretary of Council—

"That the Draft Scheme for the administration of the Cunningham Fund, submitted at the Stated Meeting of the 30th November last, be adopted by the Academy."

DRAFT PETITION.

"*In Chancery.*

"In the Matter of the ROYAL IRISH ACADEMY, and in the Matter of the 52nd George 3rd, cap. 101, intituled 'An Act to provide a summary remedy in case of abuse of trusts created for charitable purposes.'

"*To the* Right Honorable JOHN THOMAS BALL, LORD HIGH CHANCELLOR OF IRELAND.

"The Petition of SAMUEL FERGUSON, of No. 20 North Great George's-street, in the city of Dublin, Esq., Q.C., and ALEXANDER GEORGE RICHEY, of 27 Upper Pembroke-street, in the city of Dublin, Esq., Q.C., two of the members of the Council of the Royal Irish Academy,

"HUMBLY SHOWETH,

"1. Timothy Cunningham, formerly of Gray's Inn, in the county of Middlesex, duly made and executed his last Will and Testament,

should think proper, for the improvement of natural knowledge and other objects of their Institution, and the said Testator thereby appointed the Rev. Thomas Hussey sole Executor of his said Will.

"2. The said Timothy Cunningham died shortly afterwards, and his said Will was duly proved in London on the 16th June, 1789, and Probate thereof granted to the said Rev. Thomas Hussey, the Executor named.

"3. The Royal Irish Academy was incorporated by Royal Charter in the year 1786 for promoting the study of Science, Polite Literature, and Antiquities.

"4. The legacy of £1,000 was duly paid over to the said Royal Irish Academy.

"5. Under the Statutes and By-laws of the Academy all medals or other honorary rewards are from time to time to be awarded by the Council of the Academy at their discretion.

"6. Different plans have from time to time been adopted for the purpose of carrying out the intentions of the said Testator.

"7. The first plan was that of giving prizes for the best essays on subjects proposed by the Academy.

"8. This was soon afterwards altered, and 'The Cunningham Gold Medal' was instituted instead of a pecuniary prize.

"9. These Medals were for some time given for papers published in the *Transactions* of the Academy, but this plan was objected to, as narrowing too much the field of competition and diminishing in proportion the honour of the reward.

"10. In the year 1848 a new plan was substituted, which was as follows:—

"I. All Works or Essays in the departments of Science, Polite Literature, or Antiquities, which should be published in Ireland, whether in the *Transactions* of the Academy or not, or which should relate to Irish subjects, were to be considered as competing for the Medal.

"II. The Council of the Academy were to award Medals every third year, and were to take into consideration all papers or works coming under this description which had been published within the six years preceding.

"11. These regulations have been only partly acted on, the limits of time having been found inconvenient, and the regulations in that respect being deemed improvident, a further resolution was passed at a meeting of the Council of the Academy on 18th November, 1872, by which the said regulations of March, 1848, respecting the medals and premiums from the Cunningham Bequest, were repealed, and it was resolved that awards from it thereafter should be made at the discretion of the Council, limited only by the Trusts of the Testator's Will.

"12. Subsequently, on the 3rd February, 1873, a further resolution was passed by the Council of the Academy, by which the Council agreed to recommend the Academy to offer out of the Cunningham Fund two premiums of £50 each for Essays on the then present state of the Irish Language and Literature, written and unwritten, in Munster and Connaught.

"13. This recommendation was subsequently adopted at a General Meeting of the Academy, held on the 16th March, 1873.

"14. Seven Essays were sent in, but their merit being insufficient to entitle any of them to the full amount of a prize, the Council decided to divide £50 between three of the Essayists.

"15. In December, 1874, the Council offered two premiums of £50 each for the best Reports or Essays on the then present state of the Irish Language and Literature, written and unwritten, in the Provinces of Leinster and Ulster respectively.

"16. Three Essays were sent in, but none were of sufficient merit to entitle the author to a full prize; however, £20 was awarded to one of the Essayists.

"17. The Council have awarded no premiums since the year 1874.

"18. Notwithstanding the desire of the Council to give premiums, they have found that that form of encouraging learning out of said Cunningham Fund has not been successful, and that the interest of the Fund has outgrown their ability to apply it beneficially in that way.

"19. The Council are desirous that a scheme should be devised, so as to enable the Royal Irish Academy to employ the interest on the

President:

SIR ROBERT KANE, M. D., F. R. S.

The Council:

	Elected.	
(1).	Mar. 1870.	Edward Perceval Wright, M. D., F. L. S., F. R. C. S. I.
(2).	" 1872.	David Moore, Ph. D., F. L. S.
(3).	" 1872.	John Casey, LL. D., F. R. S.
(4).	" 1873.	Thomas Hayden, F. K. & Q. C. P. I., F. R. C. S. I.
(5).	" 1874.	Rev. John Hewitt Jellett, B. D., S. F. T. C. D.
(6).	" 1875.	Sir Robert Kane, M. D., LL. D., F. R. S., F. K. & Q. C. P. I.
(7).	" 1875.	Alexander Carte, M. D., F. L. S., F. R. C. S. I.
(8).	" 1875.	William Archer, F. R. S.
(9).	" 1876.	Robert Stawell Ball, LL. D., F. R. S. (*Sec.*)
(10).	" 1876.	James Emerson Reynolds, M. D., F. C. S.
(11).	" 1870.	Rev. Samuel Haughton, M. D., F. R. S., D. C. L., F. T. C. D.
(12).	" 1877.	Bindon B. Stoney, C. E.
(13).	" 1859.	John Kells Ingram, LL. D., F. T. C. D.
(14).	" 1867.	William John O'Donnavan, LL. D.
(15).	" 1869.	Alexander George Richey, LL. D., Q. C.
(16).	Dec., 1869.	John Ribton Garstin, M. A. & LL. B., F. S. A.
(17).	Mar. 1871.	Very Rev. William Reeves, D. D., LL. D., M. B.
(18).	" 1873.	Rev. Thaddeus O'Mahony, D. D.
(19).	" 1875.	Rev. Maxwell Close, M. A.
(20).	" 1875.	Robert Atkinson, LL. D.
(21).	" 1876.	Thomas Drew, R. H. A.
(22).	" 1867.	Samuel Ferguson, LL. D., Q. C.,

of whom your petitioners are two.

"21. The whole interest on the Fund constituting the Cunningham Bequest, not having been expended from time to time in premiums and medals, the present amount of the said Fund, including principal and the interest from time to time added thereto, is the sum of £2618 9*s*. 5*d*. Government new Three per cent. stock, which is now standing in the books of the Governor and Company of the Bank of Ireland, in the name of the Royal Irish Academy.

"22. The funds available for the publication of the *Transactions* and *Proceedings* of the Academy are not sufficient for that purpose, and many Papers of merit are held over, for want of adequate means for their publication.

"23. Your Petitioners submit that the interest on said Cunningham

disposal of the Council for the publication of the *Transactions* and *Proceedings* of the Academy, and that a scheme for the purpose should be settled under the direction of the Court.

"24. The proposed method of dealing with the interest of said Fund has, as your Petitioners are personally aware, the approval of the Council.

"May it therefore please your Lordship to order that it may be referred to your Lordship in Chamber to settle a scheme for the proper administration of the said Cunningham Fund, and, if your Lordship should think fit, to direct that, in settling such scheme, regard should be had to the employment of the interest on said Fund in the manner suggested by your Petitioners in paragraph 23 of the foregoing Petition; and that your Petitioners may be declared entitled to their costs of this Petition and of the proceedings, when taxed and ascertained, out of the said Fund, and that the said Royal Irish Academy, the present trustees of said Fund, may be at liberty to pay said costs, when so taxed and ascertained, thereout to your Petitioners, or that your Petitioners may have such further and other relief in the premises as to your Lordship may seem fit.

"And your Petitioners, &c.,

"WM. ANDERSON, *Counsel.*"

ORDER OF THE MASTER OF THE ROLLS.

[*Nov.* 19, 1877.]

"It is ordered by the Right Honorable the Master of the Rolls, that it be adjourned to the Judge in Chambers to approve of and settle a scheme for the future regulation of the Cunningham Bequest in the said Petition mentioned; and it is ordered, that the Petitioners do bring in and lodge in said Chambers a Draft of such scheme as they suggest for the purpose, such Draft to be first approved of by Counsel on behalf of the said Royal Irish Academy. And it is further ordered, that a copy of said Draft Scheme, when so lodged in Chambers, be also lodged with the clerk of the Attorney-General. And it is further

Draft of Proposed Instructions for the Preparation of a Scheme.

"Sir,

"The order of his Honour the Master of the Rolls, dated the 19th November, 1877, and made in the matter of the Royal Irish Academy and the matter of the 52nd Geo. 3., chap. 101, has been laid before, and carefully considered by, the Council of the Royal Irish Academy.

"His Honor by such order has directed that the Petitioners should bring in and lodge in his Chambers a draft of a scheme, and that such scheme should be settled by Counsel, and that a copy of such scheme should be lodged with the Clerk of the Attorney-General.

"The Petitioners in the matter presented the petition at the request and by the directions of the Council, and are, both they and the Council, desirous that such a scheme should be presented to the Court as may meet the views of the Counsel employed in this case, and also the wishes of the general body of the members of the Academy.

"The Council has, therefore, taken the opinion of the members of the Academy as to the nature of the proposed scheme, and have received their consent and approval to the following instructions. It is for the Counsel employed to reduce these instructions to a formal and technical shape; and these instructions are, therefore, intended merely as an expression of the wishes of the Council and the Academy as to the substance and matter of the scheme.

"The Council and the members of the Academy desire that the interest and dividends of the Cunningham Fund should be applied in the manner following:—

"1. In premiums of an honorary nature, such as medals, &c., to persons rendering eminent services in Science, Polite Literature, or Antiquities.

"2. In pecuniary premiums, to be awarded by the Council for the best Essays upon subjects to be proposed by the Council, when and as they think fit, and advertised for public competition.

"3. In the [illegible]

"4. That, subject to the making due provision for the above purposes, the Council be at liberty to apply the annual revenue and dividends towards the expenses of the publication of the *Transactions* and *Proceedings* of the Academy.

"5. That for all or any of the purposes aforesaid, numbered respectively 1, 2, and 3, the Council be at liberty to have recourse to the present or future accumulation of dividends, and to deal with the same as the revenue of the current year.

"You are requested to lay these instructions before Counsel for his guidance in the preparation of the proposed scheme."

After a prolonged debate,

It was Resolved—

"That the further consideration of the subject be adjourned to the next night of meeting."

MONDAY EVENING, FEBRUARY 11, 1878.

SIR ROBERT KANE, F. R. S., President, in the Chair.

Charles E. Burton, A. B.; George F. Fitzgerald, M. A.; Robert W. Lowry, B. A., and Michael O'Hanlon, M. D., were elected Members of the Academy.

The consideration of the Cunningham Fund Scheme was resumed, and the following amendment was adopted :—

"That the Academy accept the scheme proposed by the Council for the better administration of the Cunningham Fund, subject to such alterations (if any) as, on discussion of its details, shall seem fit; and that the Academy now proceed to consider the scheme, paragraph by paragraph, as set out in the draft of proposed instructions which Council have placed before them."

The adoption of the first paragraph of the Report of Council having been moved, the following amendment was moved and seconded :—

"That the first clause shall have the words within brackets as follows inserted therein :—

"I. In premiums of an honorary nature, such as Medals, &c.—

subjects, in rotation, viz.:—(1) Pure Science, (2) Applied Science, (3) Polite Literature and Antiquities; and] to persons rendering eminent services in Science, Polite Literature, or Antiquities."

The amendment having been negatived, the following amendment was then proposed and seconded:—

"In premiums of an honorary nature, such as Medals, with or without pecuniary premiums, to persons rendering eminent services in Science, Polite Literature, or Antiquities."

To this was added the words, "which premiums shall be awarded triennially."

A division having taken place, the amendment was negatived, and the first clause of the Draft Scheme was adopted by the Academy.

The second, third, fourth, and fifth clauses were carried unanimously.

The final clause—"You are requested to lay these instructions before Counsel, for his guidance in the preparation of the proposed scheme"—was carried unanimously.

The preamble having been accepted, the entire draft was then adopted by the Academy.

MONDAY EVENING, FEBRUARY 25, 1878.

SIR ROBERT KANE, F. R. S., President, in the Chair.

The following Papers were read:—

"A Chemical Examination of the Mixed Waters of the Estuary of the River Liffey, with Remarks on the Discharge of Sewage into Estuaries," By L. Studdert, LL. D.

"On a Unique Copy of the Life of the Virgin, by Albert Durer." By William Frazer, M. D.

"Further Remarks on the Supposed Substitution of Zinc for Magnesium in Minerals." By E. T. Hardman, F. C. S. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

"On the Acanthology of the Desmosticha," Part I. By H. W. Mackintosh, B. A. [Ordered for *Transactions*, vol. xxvi.]

"On Direct Demonstration of the Properties of the First Negative Pedal of a Central Conic from any Point on its Plane." By J. C.

Saturday Evening, March 16, 1878.

(Stated Meeting.)

Sir Robert Kane, F. R. S., LL. D., President, in the Chair.

The Ballots for President, and Members of Council, and Officers, and for Honorary Members, being opened, the President appointed J. J. Digges La Touche, William Frazer, M. D., Professor O'Looney, and The O'Conor Don, M. P., Scrutineers for the election of President, Council, and Officers; and W. J. Fitzpatrick, LL. D., and Parke Neville, C. E., as Scrutineers for the election of Honorary Members.

The Secretary of Council brought up the following Report of the Council for the year 1877–8:—

Report of Council for the Year 1877–8.

Since the date of the last Report of the Council, the following parts of vol. xxvi. of the *Transactions* have been published:—

Part 7. "The Red Stars: Observations and Catalogue." By J. Birmingham.

Part 8. "On a New Species of Parasitic Green Alga belonging to the genus Chlorochytrium of Cohn." By E. Perceval Wright, M. D.

Part 9. "On a Species of Rhizophydium parasitic on Species of Ectocarpus, with Notes on the Fructification of the Ectocarpi." By E. P. Wright, M. D.

Part 10. "A Supplement to Sir John Herschel's 'General Catalogue of Nebulæ and Clusters of Stars.'" By J. L. E. Dreyer, M. A., F. R. A. S.

And the following is in the press:—

Part 11. "On the Aspect of Mars at the Oppositions of 1871 and 1873. By C. E. Burton."

Of our *Proceedings* there have been issued within the year part 1 of vol. iii. (second series), containing Papers on Science; and part 12 of vol. i. (second series), containing Papers on Polite Literature and Antiquities.

Within the past year, Papers by the following authors were read before the Academy:—

O'Reilly; Rev. James Pearson; Professor A. Leith Adams; Mr. W. H. Bailey; Dr. Brünnow; Mr. Edward T. Hardman; Mr. H. W. Mackintosh; Mr. J. C. Malet; Mr. Thomas Bayley; Mr. Henry Hatfield; Mr. Wm. Plunkett and Dr. Lancelot Studdert; Mr. C. C. Hutchinson and Mr. A. N. M'Alpine; Mr. Reginald Lawrence and Mr. C. W. Reilly.

In the department of Polite Literature and Antiquities:—by Mr. Denis Crofton; Dr. Samuel Ferguson; Rev. J. P. Mahaffy; Mr. E. C. Rotheram; and Dr. W. Frazer.

The work of lithographing the most valuable of our Irish MSS. makes steady progress. Of the "Book of Leinster," 312 pages, being more than three-fourths of the whole, have been printed off, and 80 additional pages are on stone. The Irish scribe pursues his work with remarkable diligence, and it is expected that the remaining portion will be completed before the summer of 1879.

The whole of the triple text of the Felire of Oengus having been printed, Dr. Whitley Stokes applied for and obtained the consent of the Council to have the Glossarial Index, which is to be added, printed in Calcutta, with a view to save the time lost in the transmission of proofs between this country and India. It appeared, however, on trial, that the work could not be properly executed there. All the manuscript of the Index is now in the printer's hands, and a large portion of it is in type; and the issue of the entire work may be expected in the course of the present year.

The question pending between the Academy and the Government for a considerable time prevented progress being made in the publication of the *Annals of Ulster*. This difficulty having been removed, arrangements have been made for the immediate commencement of the printing, and it is hoped that the Council will be able, in their next Report, to announce that a substantial portion of the work has been completed.

Several interesting objects have been added to the Museum within the year. Amongst those procured by purchase are a very fine lunula of gold, a torque of the same metal, and some weapons of bronze. The donations include an ancient canoe and a singular trough-shaped vessel of oak, sepulchral urns, and other articles, presented by Mr. J. G. V. Porter, of Belleisle. For the Strong Room a movable mahogany

the most important of our ancient manuscripts. The painting and other work now in course of execution in the Crypts and Supplemental Library will, when completed, effect a substantial and much-needed improvement in those portions of the Academy's premises.

The grants in aid of the preparation of Scientific Reports, recommended by the Committee of Science, approved by the Council, and now submitted for the sanction of the Academy, are as follows:—

£25 to C. R. C. Tichborne, F. C. S., for Researches upon the general diffusion of Fluorine in Animal Concretions, &c.

£25 to E. T. Hardman, F. C. S., for Apparatus and Chemicals to enable him to continue his Chemico-Geological Researches.

£20 to A. G. More, F. L. S., for the Examination of the Flora of the South and West of Ireland.

£12 to A. Leith Adams, F. R. S., towards the expenses of collecting materials relating to the Natural History of the Irish Elk, with the view of producing a Monograph on the subject.

£18 to Rev. J. H. Jellett, B. D., for Researches on the Relations between Light and Electricity.

£70 to Professor Oswald Heer of Zurich, for an Investigation of the Tertiary Flora of Antrim.

£30 to Dr. Macalister, for purchase of rare specimens to carry out Embryological Researches.

The Council thought it their duty to address a Memorial to the Lord President of the Committee of Council on Education, calling his attention to the composition of the Committee for the administration of the grant of £4000 now annually voted by Parliament for the encouragement of Scientific Research, and urging the inadequacy of the representation of Ireland on that body. In taking this step, they acted in conjunction with the Royal Society of Edinburgh, and, besides supporting a similar claim put forward by that learned body, the Council prayed that this Academy should have in future two Representatives on the Committee, instead of one, as had been previously arranged. In reply, we were informed that, after communicating with the Royal Society, the Lords of the Committee of Council on Education had approved of the Academy having a second Representative in addition to its President; and the Council accordingly nominated Mr. Robert Mallet, a

The Academy was recently invited by the Lords of the Committee of Council on Education to nominate three persons to act as Members of the Board of Visitors, constituted, in accordance with Lord Sandon's letter of the 8th of February, 1876, to aid their Lordships in the administration of the new Science and Art Museum to be founded in Dublin, as well as of the Natural History Collections and the Botanic Gardens, which are to be associated with that establishment. The Academy accordingly nominated the Rev. John H. Jellett, Samuel Ferguson, LL. D., and Sir Robert Kane, to act on the Board.

A proposal was made to the Council of the Academy in April last by the Council of the Royal Dublin Society for a Conference between the President and Science Committee of the Academy and twelve members of the Royal Dublin Society, whose names were given, to consider certain suggestions which had been made by a Committee of the Royal Dublin Society, the most important of which was, that "it would be desirable that a Society devoted *exclusively* to Science should exist in Dublin." A correspondence between the two Councils took place on the subject, the result of which was, that the Council of the Royal Dublin Society declined to accept the Conference under the conditions which the Council of the Academy thought it necessary to prescribe. The correspondence is given in an Appendix to the present Report, which also contains a letter which the Council thought it their duty to address to the Secretaries of Her Majesty's Treasury, in relation to one of the heads of agreement between the Government and the Royal Dublin Society, embodied in the Memorandum of Provisions agreed to on the 5th of March, 1877.

It is known to the Members of the Academy that the British Association for the Advancement of Science will hold its next meeting in Dublin, in August of the present year. The Council of the Academy, at the request of the Lord Mayor, nominated several gentlemen to act on the Local Committee appointed to make arrangements for the reception of the Association. The Academy has also resolved, on the suggestion of the Council, to give a Conversazione on the occasion, as it did when the Association last visited Dublin. A subscription amongst the Members of the Academy has accordingly been opened. The Reception Committee of the Association has offered

of the Academy, are to be admissible. Having regard to the number of persons who may be expected to be present, it is obvious that a considerable sum must be provided, and, as the funds of the Academy are not available for the purpose, the Council trust they will be enabled, by the liberality of the Members, to make the Conversazione worthy of the distinction of the learned body to which it is proposed to do honour, as well as of the position which the Academy occupies in the scientific world.

The re-transfer of the charge of the Academy's annual vote from the Science and Art Department to the Chief Secretary for Ireland has been carried into effect, in accordance with the arrangement entered into with the Government.

The Treasurer reports that there is no feature in the state of the Academy's finances calling for special remark, and that he expects that the accounts for the year ending on the 31st of this month will be found satisfactory.

The Council, dissatisfied with the past administration of the Cunningham Fund, and desirous that it should be utilised in a more ample manner for the promotion of the principal objects which the testator had in view, caused to be prepared a Draft of Instructions, to be given for the preparation of a scheme to be laid before the Master of the Rolls, for the better administration of the Fund. This Draft was submitted to the Academy, with the Resolutions of the Council and other documents relating to it, and, after a prolonged discussion, was adopted by the Academy.

It is the opinion of the Council that too long an interval has been allowed to elapse without an award of medals out of the Cunningham Fund, and they recommend this subject to the consideration of their successors.

Nine ordinary Members have been elected since the 16th March, 1877, viz.:—

1. Rev. G. H. Reade, M. A.
2. Francis A. Tarleton, LL. D.
3. Benjamin Williamson, M. A.
4. C. Lloyd, M. D.
5. Charles Smith.
6. C. E. Burton, B. A.

8. R. W. Lowry, B. A.
9. M. O'Hanlon, M. D.

We have lost by death within the year seven Honorary Members:—

In the department of Science:—

1. Urbain Jean Joseph Leverrier.
2. Henri Victor Regnault.
3. Padre Angelo Secchi.

In the department of Polite Literature and Antiquities:—

1. John Lothrop Motley,
2. John Stuart,
3. Augusto Soromenho,
4. Louis Adolphe Thiers,

and eleven Ordinary Members, viz.:—

1. C. Neville Bagot, elected June 8, 1863.
2. Edward Cane, elected February 22, 1836.
3. Fleetwood Churchill, M. D., elected January 10, 1842.
4. Eugene A. Conwell, LL. D., elected January 9, 1860.
5. Denis H. Kelly, elected June 24, 1838.
6. Thomas F. Kelly, LL. D., elected January 25, 1836.
7. James C. F. Kenney, elected April 10, 1848.
8. John Mollan, M. D., elected January 13, 1840.
9. Thaddeus M. O'Callaghan, C. E., elected January 11, 1876.
10. William Stokes, M. D., elected November 29, 1834.
11. Henry Wilson, F. R. C. S. I., elected January 8, 1866.

Amongst these names, that of William Stokes naturally takes the foremost place. He was born in Dublin in the year 1804. He belonged to a family in which, as has been well said, "genius is hereditary." His father, Dr. Whitley Stokes, was a man of great ability and originality of intellect; and his honesty and independence of character were shown by his resignation, for conscientious reasons, of his Senior Fellowship in Trinity College. On his retirement from that office, he was appointed Lecturer in Natural History—a post which he filled

work his gifted son was from an early age constantly associated; and though, from his father's peculiar views on the subject of education, he was never sent to school or to the University, we cannot doubt that, under such able guidance, the powers of observation which were afterwards to make him famous were effectually cultivated. He was also a pupil of John Walker, a man of vigorous intellect and varied learning, who, as well as Whitley Stokes, had forfeited, for conscience sake, his position in the University.

William Stokes' medical studies were pursued at Edinburgh, whither he was sent in 1823. He there became the pupil and friend of Dr. Alison, whom he declared, long afterwards, to have been the best man he had ever known; and by him he was taken as his habitual companion in his charitable labours among the sick poor.

Soon after his graduation he was appointed, at the early age of twenty-two, Physician to the Meath Hospital in succession to his father; and in this institution, in conjunction with Dr. Graves, he carried out the great reform in clinical teaching which will be for ever associated with the names of these two eminent men. The essence of the new method was the systematic effort (in the words of Stokes himself) "to teach the individual pupil, to encourage him to learn, to show him how to teach himself, to bring him into the true relation in which he ought to stand with his instructor, to make him familiar with bed-side medicine, to show him the value which attends on every new fact and observation in medicine, and to make him learn the duty, as well as taste the pleasure, of original investigations."

As a clinical teacher, Stokes, as all his pupils testify, pre-eminently shone. His thorough examination of every case—his accurate and careful diagnosis—his treatment, marked at once by caution and courage—presented to the student the perfect exemplar of a practical physician. As a lecturer he possessed very remarkable gifts of lucid and forcible expression; his earnestness of manner is described as singularly impressive; and he had that special power of creating a living interest in his teaching which belongs to the original investigator, fresh from direct contact with nature. As he has himself said: "Genius, the creative power, so far as such a power is given to man, will, while it produces its golden fruits, find a descriptive language of

Already in 1825, when he was but twenty-one years of age, had appeared his first contribution to medical literature—his *Introduction to the Use of the Stethoscope*, founded on the works of Laennec and Andral, but containing much original matter, and giving clear promise of his future eminence. This work was followed, in 1828, by two lectures "On the Application of the Stethoscope to the Diagnosis and Treatment of Thoracic Disease." At this time the new instrument was far from having obtained general acceptance amongst the members of the profession. But Stokes caught up, with enthusiasm, the additional resource which had been placed at the disposal of the physician, declaring that "it had added more to the facility, certainty, and utility of diagnosis than anything that had been done for centuries."

Very soon after his appointment to the Meath Hospital he began to contribute to the medical periodicals of the day. Many Papers of his appeared in the *Dublin Hospital Reports*, the *Dublin Hospital Gazette*, the *Transactions* of the Association of the College of Physicians, and in the *Dublin Journal of Medical Science*, which, at first edited by our President, Sir Robert Kane, was afterwards, for several years, conducted by Graves and Stokes. Some of his communications to the last-named Journal were in the form of Reports of the Pathological Society, which had been founded by Stokes in conjunction with the late Professor R. W. Smith; others were of the nature of Reviews, amongst which may be particularly mentioned his notice of Calmeil's *Treatise on Insanity*, in which he points out the relations between the phenomena of the mesmeric state and those exhibited in the nervous epidemics which have appeared more than once in medieval and modern Europe.

In 1837, Dr. Stokes published the first of his great medical works—his *Treatise on the Diagnosis and Treatment of Diseases of the Chest*. This work at once established his reputation as standing in the foremost rank of clinical observers. It was received by the profession at home and abroad as a most valuable contribution to science; and honorary distinctions were conferred on its author by many medical societies on the Continent of Europe and in America. In 1854 appeared his work *On Diseases of the Heart and Aorta*, which took similar

pen, were published his *Lectures on Fever*, in which he gave the results of his vast experience in the observation and treatment of that disease—results which can never lose their value, though, in the opinion of many physicians, he did not sufficiently distinguish the several morbid affections comprehended under the general name of Fever.

We possess, besides his strictly medical writings, a valuable series of Addresses which he delivered from time to time, chiefly in the Theatre of the Meath Hospital or in the University of Dublin, in which, in the year 1845, he succeeded his father as Regius Professor of Physic. These are to an unprofessional reader the best evidence of his varied powers, and a most interesting record of his general views. He exhibits in them the attitude which all through his life he maintained in relation to the philosophy of medicine. "We have not yet," he said, "a Theory of Medicine. But at the appointed time, when the required amount of facts have been faithfully observed and recorded, they will, by one of the great properties of truth, crystallize spontaneously into a system and a law." He was, accordingly, in medical doctrine what he described Graves as having been—an Eclectic. Whilst essentially following the Hippocratic tradition, and therefore attaching primary importance to the study of symptoms in the living body, and denying the connexion of all disease with organic lesion, he admitted the vast advantage which had arisen from the researches of the pathological anatomists. He welcomed all the additions contributed by modern science to the means of diagnosis, proclaiming—as we have seen—at the very outset of his career the importance of stethoscopy, and in one of his latest discourses enumerating the aids to be derived from optics, from new applications of acoustics, and from physical phenomena generally, in the study of morbid conditions.

But in these Addresses he has also dealt with questions of a different kind, and of no less importance to the public; and these subjects so largely occupied his mind, and his views respecting them were so often put forward in his public and private discourse, that they cannot be passed over in a notice like the present. Filled with a sense of the greatness of his noble profession, he insisted again and again on the means which he judged best fitted to elevate it in general estimation and in

bear its full fruit, not merely on account of the various contacts now established between medicine and the whole range of the sciences, but because, for the true physician, what is above all things needed is the philosophic habit of mind which a large and liberal education is best fitted to produce. "Medicine," he said, "is not a handicraft, governed by a fixed rule, or any set of rules that you can learn by rote. It is not a study of fixed, but of varying conditions." Hence, he inferred, that to deal with it the mind must have the suppleness and resource which will enable it to adapt itself to complex phenomena, exhibiting from time to time new characters and varied combinations. And though no system of education will give the *mens medica*, which seems to be a gift of nature, it is evident that a general cultivation of the powers of the mind, and rational habits of observation and induction, must be the best preparation for so difficult a task.

Further, believing it to be important for mankind that the medical profession should occupy a high place in public opinion and in society, he dwelt on the necessity of a good general education with a view to this result also. He urged, that without such an education the profession would tend to degenerate into a trade, and the worst of trades; and that men whose general powers of mind had not been cultivated, whose tastes were unrefined, and who were strangers to wide and important fields of knowledge, could not maintain the dignity of the profession, or assert for it the position which it is entitled to claim.

In a similar spirit he preached the necessity of moral training, and he aimed at elevating the moral tone of the students who came under his influence; and, remarkable as he always is for the freshness and force of his style, he sometimes rises into a strain of genuine eloquence when he paints the ideal physician, and enlarges on the duties and responsibilities of a profession whose labours are a perpetual exercise of humanity, and in which, to use his own words, "honour is so indispensable and so precious that he who wants it, or who has soiled it, has no business there."

Nor was he less zealous for the material interests of his medical brethren, especially of those who were least able to vindicate their own claims. He made an effort to procure for such of them as were

Mr. Cusack gave remarkable evidence before a Committee of the House of Commons in 1843, on the excessive mortality amongst Irish practitioners, especially from the prevalence of typhus fever in this country. A demand, based on these considerations, was made for an improvement in their pecuniary position, which was partially—though unhappily only partially—successful.

Dr. Stokes always protested against what he calls "the unhappy and calamitous division of the profession into medicine and surgery." Sooner or later, he held, that factitious and unreasonable distinction would be obliterated. "The human constitution," he says, "is one; there is no division of it into a medical and surgical domain; the same laws and the same principles apply to the cure of a fractured bone and the cicatrisation of an internal ulcer." What he regarded as most essential, however, was not the fusion of the two branches of the profession, though to this he looked forward, as likely both to further the progress of science and to elevate the moral and political status of the profession, but the fundamental identity of the education of both. Advantages, as he says, no doubt arise from a practitioner devoting himself to this or that branch; but, if he seeks for eminence, he will first educate himself generally. Especially he dwells on the necessity to the surgeon of a thorough study of fever, from which more men in the British Navy died during the great French War than from all other causes, including the sword. It is, without doubt, in a great measure to the influence and arguments of Stokes that we owe the marked movement in the Dublin School towards an identical training for the physician and the surgeon.

Dr. Stokes foresaw and predicted the increasing degree in which the medical profession would be brought by the demands of modern civilization into relation with the Government of the country. In particular, as he points out, the growing sense of the importance of sanitary measures, and the gradual development of the central and local organizations for the improvement of the public health, must tend in that direction. It was mainly due to his influence that the University of Dublin established, in 1871, the Certificate of Qualification in State Medicine for such Medical Graduates as have made a special study of

of the General Council of Medical Education, of which he was nominated a Member by the Crown, and in whose labours he took an active and influential part.

In 1868 was published *The Life, and Labours in Art and Archæology, of George Petrie.* Connected with that eminent man for many years by the closest ties of friendship, and sympathizing profoundly with his sentiments and tastes, Dr. Stokes was probably better fitted than any other person to be his Biographer; and the book is a worthy memorial of the great antiquary of whom this Academy is justly proud, fully and ably describing his public services, while it paints with life-like truthfulness his gentle and loveable character. But it is much more than a biography: besides abounding in accurate information and just criticism on subjects of Art and Archæology, it gives an account, from several points of view, of that memorable period in our national history which almost deserves the name of the Irish *Renaissance.* It is more than once observed by Dr. Stokes that, during the first quarter of the present century, a noticeable apathy had come over the Irish mind; there was a marked decline of intellectual vitality and initiative. But the twenty years that followed form, he says, "the most remarkable, and not the least glorious, epoch in our history;" for it was then that a singular development of intellect and energy in almost every department of mental culture showed itself amongst us. "It was the time," he adds, "of Hamilton, the younger Lloyd, Lord Rosse, MacCullagh, Apjohn, and Robinson; in literature, of Todd, Anster, Butler, Hincks, and Petrie; in medicine, of Graves, the representative man of Irish medical science, and of many more whose labours in various paths of original investigation have advanced the honour and interests of their country." The re-awakening was felt in the University, which then began the series of reforms which has so much improved and expanded its entire system; in the Clinical teaching of the Medical School of Dublin—a School which rose into distinction with unexampled rapidity; in general and periodical literature; but nowhere was the new life which then began to stir more active than in this Academy, as the list of names we have quoted will sufficiently show. This great period is not indeed described in all its aspects in Dr. Stokes' work, but such figures and incidents as group themselves

increase of the manuscript treasures of the Academy; the foundation of its Museum—of all these the book contains a most trustworthy and interesting record. In every page appears the genuine love of the author for his country—for its scenery, its people, its traditions—and his earnest zeal for its honour and its welfare. He pleads for the preservation of our ancient monuments, for the publication of the manuscript materials of Irish History and Philology, and protests against the mistaken policy of effacing the vestiges and affections of Irish Nationality, instead of consecrating the one and developing the other as a grand portion of the common treasure of the Empire.

In 1874 Dr. Stokes was elected President of this Academy. The position was one to which he was not only entitled by his eminent services to science, but for which he was specially fitted by the breadth of views and the respect for every form of useful intellectual effort which so remarkably characterised him. None of the distinguished men who have filled our Chair had a more earnest zeal for the honour and the welfare of the Academy. Those of its officers who in a time of peril and difficulty were in constant communication with him can bear testimony to the profound interest—often amounting to painful anxiety—with which he followed everything which seemed likely to affect its fortunes, and to the sound judgment with which he early perceived what might safely be accepted, and what ought never to be conceded.

The general recognition of Dr. Stokes' eminent merits was evidenced by the many titles of honour and other distinctions which he received from learned bodies at home and abroad. The University of Dublin conferred on him the Degree of M. D. *honoris causa.* He was also Honorary LL. D. of the Universities of Cambridge and Edinburgh, and Honorary D. C. L. of the University of Oxford. He was three times President of the King and Queen's College of Physicians, and was appointed by Her Majesty the Queen as her Physician in Ordinary in Ireland. He was Honorary Member of the Imperial Academy of Medicine of Vienna; of the Royal Medical Societies of Berlin, Leipsic, and Ghent; and of several other similar scientific bodies in Europe and America. Finally, he was named in 1875 one of the Members of

admirers the excellent portrait statue of him from the chisel of Foley, which stands in the Hall of the College of Physicians, and which will present to future generations a most truthful and characteristic image of the man as he yet lives in all our memories.

Of Dr. Stokes, as he appeared in private life, this is scarcely the fitting place to speak. But those who were admitted to his intimacy can never lose the impression made by personal contact with his fine intellect and his genial nature. He was eminently a many-sided man: sensible to the charm of poetry, of painting, of music, delighting in the play of humour, responsive to every touch of tender feeling; with strong convictions, yet of a thoroughly tolerant temper; sincerely pious, without bigotry or ostentation; free from intellectual narrowness, and without the least tincture of jealousy, welcoming and honouring merit wherever it appeared. The warmth of his affections was attested by many life-long friendships, and his kindness to the poor and suffering is remembered with gratitude in many an humble home.

His life was a useful and a noble one, guided by lofty motives, and directed to worthy ends. A true patriot, he pursued, with disinterested zeal, the objects he thought most important for the interests and honour of Ireland; and his country will long cherish his memory with affectionate pride.

Fleetwood Churchill was an Englishman by birth, but, soon after having taken his Degree of M. D. at Edinburgh, settled in Dublin, and from the first devoted himself to the obstetric branch of medicine, in which he enjoyed a very extensive practice, and achieved a high reputation. His writings on the Diseases of Women, on Midwifery, and on the Diseases of Children, are works of great merit, and were long the established text-books on these subjects. In 1848 the University of Dublin conferred on him the Honorary Degree of M. D., and about the same time he was elected an Honorary Fellow of the King and Queen's College of Physicians. In 1856 he became King's Professor of Midwifery in the School of Physic. During the years 1867-8 he filled the office of President of the College of Physicians. When retiring from practice in 1875, he presented to that College his large and valuable collection of ancient and modern obstetrical works;

Appendix to Report.

[1]

"Royal Dublin Society,

"Kildare-street,

"*6th April*, 1877.

"My dear Secretary,

"The Council of the Royal Dublin Society have directed me to request you to move the Council of the Royal Irish Academy to sanction a conference between the President and Science Committee of the Academy and a Committee of the Society, composed of the following Members, viz.:—

Sir Richard Griffith, Bart., F. R. SS. L. & E.,
Vice-President, R. D. S.
The Very Rev. the Provost, T. C. D., F. R. SS. L. & E.,
Vice-President, R. D. S.
The Earl of Rosse, F. R. S.
Rev. Maxwell Close, M. A.
Professor Barrett, F. R. S. E.
Professor Hull, M. A., F. R. S.
Professor Macalister, M. D.
Howard Grubb, M. E., F. R. A. S.
Charles A. Cameron, M. D., F. R. C. S. I.
Robert M'Donnell, M. D., F. R. C. S. I.
George Johnstone Stoney, M. A., F. R. S., *Secretary, R. D. S.*

"The object of the conference would be to ascertain whether conjoint action can be recommended to the two Societies in reference to the following suggestions, which have been made by a Committee of the Royal Dublin Society, viz.:—

"'1st. It is most desirable that a Society devoted *exclusively* to Science should exist in Dublin.'

"'2nd. We deem it essential that the Scientific Society shall have

defray all such expenses as those that are borne by the private funds of the similar learned Societies assembled in London at Burlington House.'

"I am to request you to lay before the Council of the Royal Irish Academy the inclosed copy of a Memorandum of Agreement between the Royal Dublin Society and the Government, some of the provisions of which are important to be taken into account.

"I am,
"My dear Secretary,
"Yours faithfully,
"G. JOHNSTONE STONEY,
"*Secretary, Royal Dublin Society.*

"THE SECRETARY OF THE COUNCIL,
"*Royal Irish Academy.*"

MEMORANDUM

Of Provisions, supplementary to those contained in Lord Sandon's Letter of the 8*th February*, 1876, *agreed to at Meeting of the 5th March*, 1877.

Present: Sir M. Hicks Beach, M. P.; Viscount Sandon, M. P.; Mr. W. H. Smith, M. P.; Mr. John F. Waller, LL. D.; Colonel Charles C. Vesey; Mr. Samuel F. Adair; Mr. G. Johnstone Stoney, F. R. S., Secretary R. D. Society.

1. The Government will allot to the Royal Dublin Society in Leinster House such accommodation, free of rent and taxes, as in the judgment of the Government is sufficient for the functions of the Society still remaining to it in Science and Agriculture. The conditions of occupation will be the same as those accorded to the learned Societies in Burlington House.

2. The Government will propose a Grant of £10,000, to be invested by the Society, with the approval of the Government, and to be made subject to the Trusts of the present Charters, or any alterations of them, in full compensation for any proprietary right of the Society in the lands, buildings or collections, with the exception of the

list shall be made, to be approved by the Government. Provision to be made for full and free access by the public at all reasonable times to the Serials and Transactions referred to.

3. The opinion of the Librarian of the British Museum shall be taken as to any earlier editions of modern books, or duplicates, which in his judgment are not required for the National Library: and such books shall be re-transferred to the Royal Dublin Society.

4. The Society in future to provide its own staff of officers and its own printing. But the Government will authorize the Stationery Office to continue to print the Proceedings and Transactions of the Society—limiting them strictly to its Scientific work—for a period of five years from the date of the transfer of the collections, with the view of assisting the Society to re-organize itself on an independent basis.

5. The Lecture Hall, Laboratory, and the necessary offices to be reserved to the Society, or an equivalent provided.

6. The existing privileges of passing through Leinster Lawn and the Court Yard of Leinster House to be reserved to Members of the Society.

7. Subject to the consent of the Director, the collections in the Botanical Gardens and the Natural History Museum to be available, as heretofore, in illustration of the papers read before the Society.

8. Members who have joined the Society before the 1st of January, 1878, to be allowed to borrow books as at present from the Library, subject to regulations to be laid down by the Librarian, and to have free admittance to the Museum at all times at which it is open to the public.

9. The Government will either allow the Agricultural Shows of the Society to be continued in Kildare-street, affording equal facilities to those enjoyed at present, or provide, either by Grant or by lands and buildings, for a transfer of the Shows to some other convenient place. The Government will inform the Society, as soon as possible, whether the Shows will be left where they are, or removed.

10. If such transfer is effected, account shall be taken of any loss the Society may be subjected to by reason of the removal of the Shows from the centre of the City to the Suburbs, or by discontinuance of the

11. Vested interests of officers paid from public funds shall be preserved, so far as they are so paid.

12. The Society to be relieved of any expense with regard to the School of Art, from and after the passing of the Bill.

13. The Library and Collections of the Society, with the exceptions above named, to be conveyed to the Government to be placed in the proposed National Library and Museum, and to be retained in Ireland on behalf of the public.

14. The Royal Dublin Society will undertake to assist in the passage of the Bill now before Parliament, and will concur in the introduction of any clause or clauses that may be necessary to vest the Library and the Collections in Her Majesty's Government for the purpose of a Public Library and Museum.

15. The Government will be prepared, at the request of the Society, to recommend to Her Majesty to grant such a new charter or charters as, in the opinion of the Government, may be required by the altered circumstances and condition of the Society.

Signed on behalf of the above-named,

William H. Smith, *Secretary to the Treasury.*

G. Johnstone Stoney, *Secretary to the Royal Dublin Society.*

5th March, 1877.

[Mr. C. Uniacke Townshend, the other member of the deputation, concurred in this Memorandum, but was unable to attend the meeting of the Conference at which it was signed.]

[2]

"10*th of April,* 1877.

"My dear Sir,

"Your letter of the 6th inst. was considered by the Council of the Royal Irish Academy at its last Meeting, and the following Resolution was adopted, which I am directed to communicate to you for the information of the Council of the Royal Dublin Society :—

"'That the Council accedes to the desire of the Council of the Royal Dublin Society that a conference should take place between the

gentlemen, and consider the views and suggestions they may put forward, and report the same to the Council of the Academy, with such observations as they may deem expedient; but not to take part in any joint expression of opinion.'

"I am instructed to add that the Council of the Academy does not wish to be understood as entertaining with favour any proposal which would contemplate a restriction of the sphere of the Academy's operations, or would involve a radical change in its constitution.

"I am, my dear Sir,

"Yours faithfully,

"JOHN K. INGRAM,

"*Secretary of Council, R. I. A.*

"GEORGE JOHNSTONE STONEY, ESQ., F. R. S.,

"*Secretary, Royal Dublin Society.*"

[3]

"ROYAL DUBLIN SOCIETY,

"KILDARE-STREET,

"19*th April*, 1877.

"MY DEAR SIR,

"I beg to acknowledge the receipt of your letter of the 10th inst., containing a copy of a Resolution passed by the Council of the Royal Irish Academy in reference to the invitation of the Council of the Royal Dublin Society, contained in my letter of the 6th inst., requesting the Council of the Academy to sanction a conference of Committees of the two Societies, for the purpose of ascertaining whether conjoint action can be recommended to both Societies in reference to the two propositions contained in my letter.

"The Resolution of the Council of the Royal Irish Academy in effect empowers the President and Science Committee of the Academy to receive the Members of the Royal Dublin Society named in my letter, only as a Deputation.

"As this Resolution appears to have been based upon a misconception of the nature of the invitation which the Council of the Royal Dublin Society had instructed me to make, I am directed to explain

as to whether they could recommend conjoint action to the two Societies. I am desired further to explain that it was intended that any recommendations which might emanate from this conference should be looked on in the light of suggestions from a body of scientific men to the Councils of the two Societies, but should have no force to bind either of them.

"Having thus, I trust, removed any misapprehension as to the nature of the invitation contained in my letter of the 6th inst., I am desired to express the hope that the Council of the Academy will allow their Science Committee to meet the Committee of this Society in conference, to discuss and advise, and not merely to receive them as a Deputation; inasmuch as a conference of the kind proposed by the Council of this Society is alone likely to lead to any practical result.

"I am, my dear Sir,

"Yours faithfully,

"G. Johnstone Stoney,

"*Hon. Secretary.*

"J. K. Ingram, Esq., LL. D.,

"*Secretary of Council, R. I. A.*"

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[4]

"*30th of April*, 1877.

"My dear Sir,

"I have received your letter of the 19th instant, and have laid it before the Council of the Royal Irish Academy.

"In my reply to your letter of the 6th instant, I informed you of the willingness of the Council that a conference should take place between the Science Committee of the Academy and the gentlemen nominated by the Council of the Royal Dublin Society, so that these gentlemen might have an opportunity of stating and enforcing their views, and having them considered by the Committee, and that the Committee, after such consideration, might make such a Report to the Council of the Academy as they should judge expedient.

"But it is not possible for the Council to accede to the proposal

"A conclusion might possibly be affirmed by a majority of the members of the conference, and a consequent expression of opinion come to the Council, which would be at variance with the views of the Science Committee of the Academy. This would be practically to supersede on the occasion the Science Committee in the office which belongs to it exclusively, of advising the Council on all matters relating to the cultivation or interests of Science.

"I am therefore directed to inform you that the Council, whilst prepared to sanction the holding of the conference on the basis of the Resolution already communicated to you, cannot agree to such a course as is suggested in your letter of the 19th instant.

"I am, my dear Sir,

"Yours faithfully,

"John K. Ingram,

"*Secretary of Council, R. I. A.*

"George Johnstone Stoney, Esq., F. R. S.,

"*Secretary, Royal Dublin Society.*"

[5]

"Royal Dublin Society,

"Kildare-Street,

"*10th of May* 1877.

"My dear Sir,

"I have laid before the Council of this Society your letter of the 30th ult., in which you inform me that the Council of the Royal Irish Academy, whilst prepared to sanction the holding of a conference on the basis of the Resolution already communicated to me, cannot agree to such a course as is described in my letter of the 19th ult., and, in reply, the Council of this Society direct me to express, through you, to the Council of the Royal Irish Academy their regret that the Council of the Academy have not allowed such a conference to take place as was proposed by the Council of this Society.

"Such a conference would have brought together a body of scientific men, sitting apart from Agriculturists and Antiquarians, and not re-

hope that it would have been possible, through this conference, to obtain the advice of a body of scientific men upon the real question at issue, viz., What course will be best for the future of Science in Ireland, under the special opportunities which have arisen?

"It would, in the opinion of the Council of the Royal Dublin Society, have been for the advantage of Science, and for the public advantage, that this issue could have been placed before such a conference without the complications that arise from antiquarian and agricultural pursuits, and from the supposed interests of particular Corporations.

"The Council of the Royal Dublin Society wish it to be distinctly understood that, in entering upon this negociation, they have been actuated by the desire to leave no means untried whereby the scientific branches of the two Societies might in future act together. It is therefore very much to be regretted that the Council of the Academy have declined the invitation.

"I am, my dear Sir,

"Yours faithfully,

"G. Johnstone Stoney,

"*Hon. Secretary.*

"John K. Ingram, Esq., LL. D.,

"*Secretary of Council, R. I. A.*"

[6]

"*23rd of May*, 1877.

"My dear Sir,

"I beg to acknowledge the receipt of your letter of the 10th inst., and in reference thereto I am directed by the Council of the Royal Irish Academy to remind you that they have not declined the holding of the conference proposed by the Council of the Royal Dublin Society, but have agreed to it, on the only basis on which it seemed to them it could be properly held. This they did through respect for the Council of the Royal Dublin Society, and because they thought the conference, rightly conducted, might have led to useful results. It must, however, be understood that in their opinion the Council of the Royal Dublin Society, in devising measures for the promotion of general

Charter of the Society, it is not authorised to deal. It was established for the promotion of Husbandry and the useful Arts, and has never obtained authority to undertake the cultivation of abstract Science.

"The Council, however, have observed with regret that some Members of the Society are seeking to divert it from its proper functions which it has discharged with honour to itself and advantage to Ireland, and to embark it in the new career of the promotion of abstract Science, The effect of this course of proceeding, which is quite unwarranted by its existing Charters, is to engage it in a permanent competition with the Royal Irish Academy, by which Science, in the largest sense, has (in accordance with its Charter) been cultivated; and this competition will, it is believed, be injurious to both Bodies, as well as to the country at large, which will lose the services in relation to industrial subjects hitherto rendered by the Royal Dublin Society.

"The Council have therefore felt it their duty to make a representation on the subject to Her Majesty's Government, a copy of which I have been instructed to send you, for the information of the Council of the Royal Dublin Society, as soon as I shall be in possession of an acknowledgment of its receipt by the Government Department to which it has been addressed.

"I am, my dear Sir,
"Very faithfully yours,
"JOHN K. INGRAM,
"*Secretary of Council.*

"GEORGE JOHNSTONE STONEY, ESQ., F. R. S.,
"*Secretary, Royal Dublin Society.*"

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[7]

"ROYAL IRISH ACADEMY HOUSE,
"DUBLIN, 22*nd of May*, 1877.

"GENTLEMEN,

"I am directed by the Council of the Royal Irish Academy to ask your attention to one of the heads of agreement between the Government and the Royal Dublin Society, embodied in the Memorandum of Provisions agreed to on the 5th of March last.

under the name of the 'Dublin Society for promoting Husbandry and other useful Arts in Ireland.'

"A supplemental Charter was granted in 1866. Nothing is enacted in it respecting a change of the objects of the Society, which is described as the Dublin Society for the Promotion of Husbandry and other useful Arts and Sciences in Ireland. The intention was plainly not to alter the sphere of labour which it had always honourably fulfilled, namely, that of advancing the Agricultural and Industrial interests of the country; and the phrase 'useful Arts and Sciences' shows that it was meant still, as before, to occupy itself, not with abstract Science (which had been provided for in the Royal Irish Academy), but only with Science in relation to its industrial or economic applications. The fact of some Papers not answering to this description having been read at its Meetings in recent years cannot affect the true character of the Society, or the correct interpretation of its Charters and its history. At present, however, as we have reason to know, some of its most active Members entertain the project of diverting it from the objects which it was founded to promote, and embarking it in the cultivation of abstract Science. To enable it to alter its character in this way, a new Charter would be necessary.

If such a Charter should be sought, it will become the duty of the Royal Irish Academy, which was established by Royal Charter for the cultivation of Science, in the largest acceptation of the word (as well as of other studies), and has fully and faithfully discharged its duty in that field, to represent to the Government the impolicy of public resources being used for the establishment in a city like Dublin of a second Society, which would occupy the same intellectual domain, and thus carry on an active competition, with the Royal Irish Academy; whilst, on the other hand, Ireland would be deprived of the valuable services, in relation to industrial subjects, which are performed for England by the Society of Arts, and have hitherto been rendered to this country by the Royal Dublin Society.

"But the point to which the Council desire at present to ask the attention of the Government is a less general one, which, however, requires more immediate notice.

"In Article 4 of the terms of agreement lately entered into

to print the *Proceedings* and *Transactions* of the Society, limiting them strictly to its scientific work, for a period of five years from the date of the transfer of the collections referred to in preceding Articles. We believe that the intention of the Government, in using the words 'limiting them strictly to its scientific work,' was not to sanction indirectly an enlargement of the sphere of the Society's operations, or the diversion of them into a new channel, but to exclude such publications as might relate to the practical action of the Society in connexion with Agriculture. And if the words be so interpreted, we are far from objecting to the privilege thus accorded to the Royal Dublin Society. On the contrary, we regard it as dictated by the kindest feelings, and as a seasonable and thoughtful aid to the Society, whilst reorganising itself on an independent basis. But we have reason to believe that the intention is entertained by some Members of the Society to take advantage of the word 'scientific,' used in this Article, as if it authorised the printing of matter belonging to abstract, as distinguished from practical Science, and to the exclusion of Industry and Art. This, we beg to represent, cannot be done under the existing Charter of the Society, and we must respectfully express our opinion that it would be a misapplication of public funds to use them for that purpose.

"The Council, therefore, humbly submit that the word 'scientific' in Article 4 must be construed as relating, not to abstract Science, but to the practical application of Science in the useful Arts, and that no Papers of the former class, which may be proposed for publication by the Royal Dublin Society, should be printed at the public expense, so long, at least, as that Society is governed by its present Charter. And if it should be proposed to grant a new Charter, with such extended powers as have been above referred to, the Council respectfully claim to be allowed to submit to Her Majesty's Government their reasons for objecting to the adoption of such a course.

"I am, Gentlemen,

"Your obedient Servant,

"(Signed) John K. Ingram, LL. D.,

"*Secretary of the Council.*

[8]

"*26th of June*, 1877.

"My dear Sir,

"Having received an acknowledgment of the receipt of the Council's communication to Her Majesty's Treasury, I hasten to send you, as I promised, a copy of it, for the information of the Council of the Royal Dublin Society.

"I am,

"My dear Sir,

"Yours faithfully,

"John K. Ingram,

"*Secretary of Council, R. I. A.*

"George Johnstone Stoney, Esq., F. R. S.,

"*Secretary, Royal Dublin Society.*"

The Report was adopted.

The list of recommendations of Scientific Grants was read and proposed by the Secretary for adoption by the Academy:—

£25 to C. R. C. Tichborne, F. C. S., for Researches upon the general diffusion of Fluorine in Animal Concretions, &c.

£25 to E. T. Hardman, F. C. S., for Apparatus and Chemicals to enable him to continue his Chemico-Geological Researches.

£20 to A. G. More, F. L. S., for the Examination of the Flora of the South and West of Ireland.

£12 to A. Leith Adams, M. D., F. R. S., towards the expenses of collecting materials relating to the Natural History of the Irish Elk, with the view of producing a Monograph on the subject.

£18 to Rev. J. H. Jellett, B. D., for Researches on the relations between Light and Electricity.

£70 to Professor Oswald Heer of Zurich, for an investigation of the Tertiary Flora of Antrim.

The Grants to Mr. Tichborne, Mr. Hardman, Mr. More, Dr. Leith Adams, Rev. J. H. Jellett, and Dr. Macalister, were adopted without a division; but the recommendation of £70 to Professor Oswald Heer was negatived on a division.

It was proposed by Dr. Lyons, and seconded by Dr. M'Sweeny—

"That it be referred back to the Council to reconsider the allocation of the sum of £70, not yet granted, in connexion with the Tertiary Flora of Ireland; and that the Council is hereby empowered to allot the Grant specified in the manner that shall now seem best to them."

The following amendment was proposed by the Secretary of Council:—

"That the words relating to 'the Tertiary Flora of Antrim' be omitted."

The amendment having been negatived, the original motion was carried.

The Scrutineers having duly reported, the President declared the following duly elected as President and Council for the ensuing Session:—

PRESIDENT.

SIR ROBERT KANE, LL. D., F. R. S.

COUNCIL.

Committee of Science.

Edward Perceval Wright, M. D., F. L. S.; David Moore, Ph. D., F. L. S.; John Casey, LL. D., F. R. S.; Thomas Hayden, M. D.; Rev. J. H. Jellett, B. D., S. F. T. C. D.; Alexander Carte, M. D., F. L. S.; William Archer, F. R. S.; Rev. Samuel Haughton, M.D., F. R. S.; Bindon B. Stoney, M.A., C.E.; Robert S. Ball, LL. D. F. R. S.; Edmund Davy, M. D.

Committee of Polite Literature and Antiquities.

John Kells Ingram, LL. D., F. T. C. D.; William J. O'Donnavan, LL. D.; Alexander G. Richey, Q. C., LL. D.; John R. Garstin, LL. B., F. S. A.; Very Rev. W. Reeves, D. D.; Rev. Thaddeus

Dr. Ingram having stated to the Academy his intention of resigning his position of Secretary of the Council, the following Resolution was passed unanimously:—

"That the Academy, in accepting the resignation of Dr. Ingram, desire to express their high sense of his distinguished and constant services, and their sincere regret at his retirement."

The Ballot was then opened for the election of Officers; and the Scrutineers having reported, the President declared the following duly elected:—

Treasurer.—John Ribton Garstin, LL. B.

Secretary of the Academy.—Robert S. Ball, LL. D.

Secretary of Council.—Robert Atkinson, LL. D.

Secretary of Foreign Correspondence.—William Archer, F. R. S.

Librarian.—J. T. Gilbert, F. S. A.

Clerk of the Academy.—Edward Clibborn, Esq.

The following gentlemen were declared by the President, on report of the Scrutineers, duly elected Honorary Members:—

In the Department of Science.

Louis Pasteur, Paris.
Sir William Thomson, Glasgow.

In the Department of Polite Literature and Antiquities.

Dr. George Curtius, Leipsic.
Henry Bradshaw, Cambridge.
Dr. H. Kern, Leyden.
Charles Newton, London.

The President, under his hand and seal, nominated the following as Vice-Presidents for the year 1878–79:—

Samuel Ferguson, LL. D.; Thomas Hayden, M. D.; Alexander Richey, LL. D.; Rev. Samuel Haughton, M. D.

MONDAY EVENING, APRIL 8, 1878.

SIR ROBERT KANE, LL. D., F. R. S., President, in the Chair.

By permission of the Academy, Professor Robert Galloway read a Paper "On the Extraction of Iodine and Bromine from Kelp."

[This Paper will appear in the *Proceedings*, Ser. ii., vol. iii., Science, part 2.]

Dr. E. P. Wright, F. L. S., read a Paper—"Notes on Algæ No. 2; On the Development of the Cell Structure and of the Antheridia in Griffithsia; On the Development of the Siphons and Tetraspores in Polysiphonia

[This Paper will be published in vol. xxvi. of the *Transactions*."]

Donations to the Library were announced, and thanks voted to the donors.

MONDAY EVENING, MAY 13, 1878.

SIR ROBERT KANE, LL. D., F. R. S., in the Chair.

Rev. John O'Reilly, C. C.; George L. Cathcart, Jun., M. A; John Browne, Esq.; Professor Robert Galloway, and John Kane, Esq., were elected Members of the Academy.

E. W. Davy, M. D., read a Paper "On a New Chemical Test for Carbolic Acid, and its Useful Applications."

[This Paper will appear in the *Proceedings*, Ser. ii., vol. iii., Science, part 2.]

The Right Rev. the Lord Bishop of Limerick read a Paper "On Two Ancient Inscribed Monuments."

The Secretary read Papers by J. C. Malet, M. A., "On a Certain Surface derived from Quadrics," and "On an Elementary Proof that every Equation has a Root."

[This Paper will be published in vol. xxvi. of the *Transactions*."]

The Secretary read a Paper by Mr. O'Dowling "On Celtic Names in the Tyrol and Carinthia."

MONDAY EVENING, MAY 27, 1878.

SIR ROBERT KANE, LL. D., F. R. S., in the Chair.

Rev. John O'Reilly, Dr. O'Hanlon, Mr. J. Kane, and Mr. C. C Burton signed the Roll, and were admitted Members.

A. S. Hart, LL. D., Vice-Provost, T. C. D., read a Paper "On the Intersections of Plane Curves of the Third Order."

[This Paper is published as part 13, vol. xxvi. of the *Transactions.*]

The President delivered the following Address on the occasion of the delivery of the Cunningham Medals to Dr. Aquila Smith, Professor Casey, Professor Dowden, and Professor Allman:—

"GENTLEMEN,

"Among the duties which devolve upon your President, there is none more honourable, and certainly none more agreeable, than that of acting as the organ of the Council and of the Academy in conferring the Cunningham Gold Medals upon those distinguished men who may from time to time be selected on account of their eminent literary, scientific, or archæological merits to receive that highest honorary reward by which, in this country, intellectual distinction is recognised. It is now a period of six years since, under the Presidency of my excellent predecessor, Rev. Dr. Jellett, the Council and the Academy conferred upon Sir William Wilde, whose loss we all so much regret, the Cunningham Medal, in recognition of his great merits in preparing *The Illustrated Catalogue* of our Museum—a work which rendered the treasures of that unequalled collection known and appreciated by all students of Archæology and Art, and has redounded, as we have frequent example, to the great credit and usefulness of the Academy. Since that time the labours of the Academy, and the original researches of our Members, have been prosecuted with so much success, and in such varied fields, as has worthily sustained the character of this Institution among the learned bodies of Europe, and has afforded to the Council an area of selection for that honour which rendered their decision, among so many, very difficult. The Council, having regard to the constitution of the Academy, including the great divisions of Literature, Science, and Antiquities,

sideration, to award on this occasion four Gold Medals, viz., one to Dr. Aquilla Smith, for his inquiries into Irish Numismatics; one to Dr. Casey, for his important mathematical discoveries; one to Professor Dowden, for his literary writings, especially in the field of Shaksperian criticism; and one to Dr. G. J. Allman, for his researches into the natural history of Hydrozoa. It will be observed that the Academy has now waived the somewhat narrow condition which had limited the works for which this honour could be awarded to those published in its *Transactions*, or on subjects immediately connected with this country. In selecting for this mark of their approval the works of Professor Dowden, which have for their subject him who was the poet not of one country but of humanity—not of one period but of all time—the Council has worthily expanded the range of influence of the Academy, and has brought our intellectual life into kindred and fellowship with the intellects of other lands, so that the distance and separation from other centres of intellectual activity, which had been on so many occasions objected to our country, can no longer be considered to apply.

I should be thought unpardonably presumptuous, did I attempt to describe with any detail the grounds upon which the Council founded their decision as to these Medals, or were I to comment with any affectation of authority on the works of the distinguished persons who are to receive them. I shall venture, only in a general way, and very briefly, to indicate the nature of the researches which in each case have been specially designated by the Council as deserving to be crowned with the approval of the Academy.

The study of Numismatics has been paralleled by an eminent Geologist with that of Palæontology, as representing, in regard to history, a series of facts recorded in the concrete material of coins and medals, fixing the order of succession of dates and events, as fossil remains characterise the succession and relative dates of geological formations, but leaving the philosophical interpretation of the cosmical or political changes by which those facts were caused to be discussed on other grounds and with further sources of information. The study of coins has thus afforded to history and to political science, as the study of fossils has afforded to geological science, important means of definition and control; and Dr. Smith, by the

Transactions, to the *Journal of the Kilkenny Archæological Society*, and to other Journals, has supplied important materials for the elucidation of many obscure points in Irish Mediæval History. Thus in his Papers on the "Irish Coins of Edward IV. and of Henry VII." we find incidentally raised the curious question as to the coins of Edward V. on which appears the title of *Rex Hiberniæ* instead of the usual *Dominus Hiberniæ*—which change, it has been ingeniously suggested by Dean Butler, was made by the Yorkist faction to engage for the impostor Lambert Simmel that instinctive devotion of the Irish people for the royal title, independent of personal merit or constitutional principle, which has been so frequently displayed. These Papers, which at once established Dr. Smith's character as an acute and accomplished Numismatist, were followed up by others on the Anglo-Saxon coins, and on the Scottish coins and tokens found in Ireland, others again on the Irish coins of Mary, and on the moneys of necessity coined in Ireland of debased materials, as brass and pewter, in the calamitous periods of the first Charles and of the second James. Another subject of Dr. Smith's researches was that of the coinage of the great Anglo-Norman nobles, whether of the de Lascis in Ulster, exercising the rights of feudal sovereignty, or as the FitzGeralds and the Ormondes, acting by authority of and as representatives of the Crown. He also directed his attention to the subject of the tradesmen's tokens coined of silver and copper in Ireland, and has thereby collected materials for illustrating many points in the industrial history of this country. All these careful and laborious inquiries afford valuable aid to the historian; but we owe to the zeal and patriotism of Dr. Smith far more than even such literary contributions. The collection of Irish coins formed by Dr. Smith during his inquiries, and which it had been sought to obtain for the Museums of the sister kingdom, has become, owing to his national spirit and liberality, the property of this Academy, and being augmented by the collections of Dean Dawson and of Dean Butler, which were similarly acquired, render the Numismatic treasures of this Academy such as any Museum or any country may be justly proud of.

For such labours, and on such grounds, the Council have decided to confer upon Dr. Aquilla Smith a Cunningham Medal, and in that award I have no doubt the Academy heartily concur. I have now,

It will be within the knowledge of many of our Members, that of late years mathematicians have been much occupied with the investigation and development of a new Algebra, transcending in its power of generalization the methods of analysis previously known. This new Calculus may be said to have originated with my late distinguished and lamented colleague Dr. Boole. Subsequently, it has been developed by the labours of Sylvester and of Cayley in England, by the writings of Rev. Dr. Salmon in this country, and by several eminent foreign mathematicians. Among the most important investigations by which this new branch of Science has been enriched in its geometrical relations are those recently published by our colleague Dr. Casey. To those investigations so much value is attached by competent mathematical authorities, that the Council of this Academy did not hesitate to award to Dr. Casey, in recognition of their merit, a Cunningham Gold Medal. I shall attempt, though very briefly, and I fear imperfectly, to notice the general nature of those Papers.

Among Dr. Casey's earlier contributions to this higher modern geometry, is a memoir which was published in volume ix. of the *Proceedings* of this Academy. This Paper contains a number of new and remarkable theorems, with respect to the Contact of Circles and Spheres, as well as some extensions to Conic Sections. But in a historic notice of Dr. Casey's labours, this Paper is of especial interest, inasmuch as it contains the germ of those new analytical methods which he has developed with such extraordinary success in his subsequent works. The principal features of these methods are well illustrated in the great Paper on "Bicircular Quartics" which he laid before this Academy in February, 1867, and which appears in volume xxiv. of our *Transactions*.

The curves known as bicircular quartics are a peculiar class, included under the more general designation of curves of the fourth degree. The properties of these curves had been already, to some extent, investigated before the commencement of Dr. Casey's labours, but it was found that the ordinary Cartesian analysis is not sufficiently tractable to be applied to this particular class of curves with advantage; and consequently, before Dr. Casey's work appeared, the true geometrical relations of these curves had been but imperfectly apprehended. By a most elegant analytical conception, Dr. Casey placed the true

to which we are accustomed in the Cartesian co-ordinates; and the general equation of the second degree, with this new interpretation of the variables, denotes a bicircular quartic in its most general form. The advantages of this mode of representation are easily seen. In the first place we are at once enabled to utilize our abundant information about the properties of a binary quartic in order to ascertain the properties of a bicircular quartic, while in the second place the peculiar analytical mechanism is exquisitely adapted to the investigation of the focal properties which are of so much importance in curves of this description.

The powerful instruments of research thus created by Dr. Casey have been applied by him to the study of the properties of these curves, and he has not only discovered a large number of new theorems, but he had so co-ordinated and arranged the whole theory as to constitute the bicircular quartics into an important branch of modern Geometry.

The conspicuous success of this analytical method in the plane has naturally suggested to Dr. Casey the study of the corresponding theory in space, of three dimensions. Little was indeed known of the important class of surfaces called Cyclides, until Dr. Casey brought his new analysis to bear upon them. As one of the most immediate consequences of this application, he discovered that a Cyclide is the envelope of a variable sphere, whose centre moves in a given quadric, and which cuts a given fixed sphere orthogonally. The complete development of the theory of the Cyclide was published in *The Philosophical Transactions* for 1871.

In his next great memoir, "On a New Form of Tangential Equation" (*Phil. Trans.*, 1877), Professor Casey has turned his attention to a somewhat different department of mathematical research. The co-ordinate of a variable line may be defined by the angle which it makes with a fixed line, and by the length of the intercept measured from a fixed point on the fixed line. An equation between these co-ordinates is termed by Dr. Casey the tangential equation of the envelope of the line. This form of equation lends itself with surprising facility to many geometrical investigations, of which abundant examples will be found in the memoir referred to. One of these discoveries is so important

maticians show that the high reputation which Dr. Casey holds as a mathematician in this Academy is sustained by the opinion in which he is held by mathematicians all over the world. Under such circumstances, I feel sure the Academy will cordially agree with the Council in conferring upon Dr. Casey the Gold Medal which I now feel honoured in presenting to him.

In order to bring under the notice of the Academy the grounds upon which the Council have awarded a Cunningham Gold Medal to Professor Dowden for his literary works, especially in the field of Shaksperian criticism, it is necessary that I should briefly indicate the point of view from which the labours of that gentleman in the field of æsthetic scholarship and psychological analysis may most consistently be considered, with reference to his studies of the life and writings of the Great English Dramatist.

There are two different ways in which the works of some great writers admit of being studied; we may, according to the ordinary usage of critics, consider their productions separately, examining their characteristic features, appreciating their æsthetic excellence and dwelling on their moral significance; or again, in the cases of those who have left us sufficiently numerous and varied products of their genius, we may consider the further question, often still more deeply interesting, according to what laws of progression did the genius of the author develope itself, and the firmness and sureness of his execution increase; how did his views of life gradually form themselves, and arrive at greater width and clearness; how were his moral convictions shaped and fixed; what was the final attitude of his thought and sentiment—in a word, we may seek through his work in some measure to reach himself, to read in some degree the history of his mind.

To arrive at even an approximate answer to these questions, in the case of a nature so rich and so many-sided as that of Shakspere, would evidently be an achievement of no ordinary interest and importance.

Now, before any considerable progress could be made in such a research, a previous condition must be satisfied. It was necessary that a chronological arrangement of the poet's work, sufficiently com-

The knowledge on this subject was long very imperfect, and the current opinions about it largely conjectural; but since the time of our countryman Edmund Malone, who first undertook this inquiry, scholars have accumulated a mass of evidence, founded partly on contemporary documents which have been brought to light, partly on references in the plays themselves, as to their respective dates; and, in recent years, a study of what are called verse-tests, founded on the regularly changing characters of the poet's versification throughout his career, has been prosecuted with much assiduity, and with a large measure of success. The results obtained by this last method are in entire harmony with the external evidence, and enable us to supplement its deficiencies; and thus a chronological scheme has been constructed, which all competent judges have agreed in accepting as, in its essential features, placed beyond reasonable question.

Now, first, by the aid of these discoveries, for such they deserve to be called, our judgment of the poet's works, from the æsthetic side, becomes more rational. The products of his different periods are considered apart, and are estimated according to a relative, not an absolute standard. The slight sketches of his almost boyish years are not placed alongside the highest efforts of his maturity; and instead of being tempted, with some of his worshippers, to maintain the existence of an equally high standard of excellence in all the poet's work, we are enabled, without compromising our reverence for his mighty genius, to admit the inferiority of his early productions, and recognise in the history of his, as of every other mind, the presence of growth and development.

But further, as is indicated above, when the path has been thus prepared, we can approach with some prospect of success the ulterior problem, behind and through the works to find the man, to understand what no external record tells us, not merely what he sang or painted, but what he was; in what succession his great powers unfolded themselves, how his conceptions of men and things broadened with his larger experience: what were his ripest and ultimate convictions respecting human nature and human duty, and what, in general, the final outcome of his spiritual life.

It is chiefly for the valuable contributions of Professor Dowden to this inquiry, that the Council has conferred on him the honour which

degree fitted for the conduct of such a research, by combining in himself several qualifications but seldom united. To the clear insight of the critic he adds the sympathetic enthusiasm of the poet; and with Shakesperian learning, with all that has been written on Shakesperian subjects, whether at home or abroad, he is, perhaps, more conversant than any other living scholar. He has thus been enabled to furnish what the voice of the best judges pronounces to be the best extant solution of the profoundly interesting question to which I have referred, and to produce a work which has not merely achieved a great present success, but will long continue, as I believe, to be the cherished companion and guide of the Shakesperian student.

These general remarks will have sufficiently indicated the spirit in which Professor Dowden has discussed the æsthetic and psychological characteristics of the personages of the Shaksperian drama. It would be impossible for me to notice in detail his treatment of those subjects, but I may venture to point out his masterly comparison of the mental peculiarities of Romeo, of Hamlet, and of Brutus. Those grandly elaborated types of tragic passion, each of whom by the overmastery in the one of sensuous emotion, in the second of abstract meditation, and in the third of stoic idealism pervading their mental nature, had lost the faculty of dealing suitably with the requirements of practical life, and, having become the mere instruments in events which they had lost all power to control, were led on to those tragical issues of which we have all read with interest and sympathy. His critical appreciation of the variety in Shakspere's treatment of the supernatural as an element of dramatic composition appears to me also peculiarly just and elegant, where he contrasts the earlier period when genial and playful Puck, Oberon, and Titania, carry on the amusing mystifications of the "Midsummer Night's Dream," with the later period where the horrid witchery of Demoniac chants lures Macbeth to his fate by double meanings; and, finally, where with the kindly grace of Ariel, and the wisdom of Prospero supernaturally matured, such powers are shown to be employed only as ministers of justice and of mercy, to be surrendered, once that the good object of their exercise has been accomplished.

Although for some years back Dr. Allman has transferred his personal activity to the wider field of the sister kingdom, yet he has never ceased to be heartily and thoroughly identified with this Academy, and with this country. It will, therefore, not require many words to explain to the Academy the grounds on which the Council decided to confer on him a Cunningham Gold Medal.

The varied and beautiful forms of life which under the names of Zoophytes, of Polypes, or of Anthozoa, the corals and sea flowers, have excited so much popular interest and have been objects of so much instructive inquiry, were, even after the recognition of their animal nature, considered until lately to belong exclusively to the lowest stage of animal existence, the Radiata of Cuvier; and their structure was supposed to be only the elementary form of a digestive sac, whose aperture was surrounded by retractile arms, to which nutriment was conveyed by vibrating cilia, expanded over the solid base or polypodome to which the associated organisms belonged. It was, however, discovered that, among the bodies usually known as Polypes, great diversity of habits and of structure could be observed. Among the first to recognise this diversity, and to point out that certain forms of Polypes were of much higher organization than others, and should occupy a much higher place in zoological classification than had been previously supposed, was our fellow-countryman, Mr. J. V. Thompson, already distinguished by his remarkable discovery of the larval metamorphoses of certain of the Crustacea, but unhappily since so prematurely lost to Science. His observations, verified and followed up by various foreign naturalists, were extended and completed by Professor Allman with admirable skill and perseverance, great originality of thought, and closeness of reasoning, in the remarkable series of memoirs by which the history of these animals has been entirely remodelled, and placed on its really scientific basis, their extraordinary phases of reproduction made known, and their true position in the scale of organic existence demonstrated.

I have said that the result of the researches of Dr. Allman and of his fellow-labourers in the same field, of whose merits he has on all occasions in his writings shown himself most scrupulously and delicately appreciative, has been to prove that certain classes of the

highest invertebrate type, that of the Mollusca; assimilating themselves most closely to the forms of the compound Tunicated Ascidians, in some of which many of the most eminent naturalists of the present day are disposed to trace the primordial rudimentary source of the vertebrata, the very highest type of animal organization.

This important discovery was announced in the remarkable Paper read by Dr. Allman to this Academy in 1852, and published in volume xxii. of our *Transactions*. Since that time he has continued, by Papers in the Scientific Journals, by Reports to the British Association, and by the admirable monographs published by the Ray Society, to illustrate and advance our knowledge of the structure, the morphology, and the physiology of these tribes of organisms. In doing so, he was obliged to create a new nomenclature, which has now been universally approved and adopted into biological literature. These classes of animals are therefore entirely removed from the true radiate Polypes. They are now known to Science as Hydrozoa and Hydroids, and their position is fixed by certain relations with the Ascidian Molluscs, to which, as I have said, they show close affinity.

Nor is the interest of Dr. Allman's researches limited to the living forms of animal life. I am informed by eminent geological authority that he has also thrown new light upon some of the most obscure questions of palæontology, and that the Graptolites of the Silurian system, almost the oldest and most mysterious forms of palæozoic existence, are now known by Dr. Allman's investigations to have been Hydrozoa.

The extraordinary series of transformations exhibited by many of these animals, in virtue of a process of alternate generation by ovules and by buds, has been specially illustrated by Dr. Allman in his "Monograph on the Hydroida" published by the Ray Society. That the medusæ, the sea nettles, which swim about our coast, and which in their countless myriads light up with gleaming phosphorescence the darksome waste of ocean, should be but highly developed buds of polypoid forms, must strike the scientific equally as the popular mind with surprize and admiration. That such wandering forms, endowed with powers of locomotion, with organs of higher sense, with sight and hearing, of course in imperfect and rudimentary

these are indeed wonders of creation, for a knowledge of which we are indebted to these who have laboured with so much zeal and well-merited success in these interesting fields of Science. Amongst these our countryman and colleague holds the foremost place. I could, were it required, in confirmation of the eminent position that Dr. Allman holds in the world of Science, repeat to you the eulogistic terms in which his labours have been referred to by the most distinguished foreign authorities, but of such quotation there is no need. That he has been elected to the office of President of the Linnean Society of London is in itself the verdict of the Biologists of the United Kingdom, and of Europe. In thus honouring him we must all feel that we do honour to ourselves and to our country.

The Academy will concur in my regret that we have not the pleasure of presenting this Medal to Dr. Allman in person, but my friend the Rev. Dr. Haughton will take care that the Medal shall be duly forwarded and delivered to Dr. Allman, by whom he has been requested to receive it on his part.

A vote of thanks to the President for his Address was proposed by Professor Hennessy, seconded by Professor Haughton, and was carried by acclamation.

Dr. Smith, Professor Casey, and Professor Dowden were present and received their Medals from the President.

Professor Allman not being able to come to Dublin, the Medal awarded to him was received on his behalf by Professor Haughton.

Donations to the Library were announced, and thanks voted to the Donors.

MONDAY EVENING, JUNE 24, 1878.

SIR ROBERT KANE, LL. D., F. R. S., in the Chair.

Joseph A. Beatty, Esq., William J. Corbet, Esq., and Rev. William A. Reynell, B. D., were elected Members of the Academy.

The Rev. H. Lloyd, D. C. L., Provost, T. C. D., read a Paper "On

By permission of the Academy, Mr. E. T. Hardman read a Paper "On an Undescribed Mineral from near Carnmoney Hill, near Belfast."

[This Paper will appear in the *Proceedings*, ser. ii., vol. iii., Science, part 2.]

Professor O'Reilly exhibited and described a Plan of 200 Basaltic Columns, with Angular Measurements.

[This Paper will be published in vol. xxvi. of the *Transactions.*]

By permission of the Academy, Mr. E. Lapper read a Paper "On the Distillation Products of the Saccharates of Ammonium and Ethyl-ammonium."

[This Paper will appear in the *Proceedings*, ser. ii., vol. iii., Science, part 2.]

By permission of the Academy, Dr. Chichester Bell read a Paper "On Further Observations on Pyrrol and its Derivatives."

[This Paper will appear in the *Proceedings*, ser. ii., vol. iii., Science, part 2.]

Donations to the Library were announced, and thanks voted to the Donors.

The Treasurer laid on the table the following Abstract of the Academy's Accounts for the year ending 31st of March, 1878, as audited by William Archer, F. R. S., and William J. O'Donnavan, forming the Committee of Audit.

The Academy was then adjourned to November.

ROYAL IRIS

GENERAL ABSTRACT OF THE ACCOUNT OF JOHN RIBTO

FOR THE YEAR ENDI

RECEIPTS.	For Special Purposes.	For General Purposes.	Total of each Class.
	£ s. d.	£ s. d.	£ s. d.
Balance from last Year,	8 9 6	3 18 5	12 7 11
From PARLIAMENTARY GRANTS:—			
Unappropriated:—"Old Grant,"	. . .	500 0 0	
Appropriated:—			
Preparation of Scientific Reports, . . .	130 0 0		
Library, ...	200 0 0		
Researches in connexion with Celtic MSS.,	200 0 0		
Publication of ditto, ...	200 0 0		
Museum, ...	200 0 0		
Purchase of Treasure Trove, ...	100 0 0		
Illustration and Printing of "Transactions" and "Proceedings,"	200 0 0		
Opening the Academy in the evening, . .	152 7 4		
			1882 7 4
„ TRINITY COLLEGE GRANT towards reproduction of the MS. known as the Book of Leinster (on account of £700) making £500,	80 0 0	. . .	80 0 0
„ MEMBERS' PAYMENTS:—			
Entrance Fees, ...	. . .	47 5 0	
Annual Subscriptions, ...	. . .	373 16 0	
Life Membership Composition (*invested as opposite*), ...	70 7 0		491 8 0
„ PUBLICATIONS SOLD:—			
Transactions, ...	. . .	26 1 8	
Proceedings, ...	. . .	5 18 10	
„ Irish MSS. Series, ...	. . .	1 0 4	
Leabhar Breac, ...	. . .	20 15 0	
Leabhar na h-Uidhri, ...	. . .	8 11 0	
Museum Catalogue (*invested as opposite*), .	3 10 7		
			65 17 5
„ INTEREST ON INVESTMENTS:—			
Life Composition—Consol. Stock, . . .	. . .	76 3 10	
Cunningham Bequest—New 3 per cent. Stock (*see opposite*), ...	76 14 3		
Museum Catalogue—Bank of Ireland Stock (*see opposite*)	[illegible]		

CADEMY.

ARSTIN, TREASURER OF THE ROYAL IRISH ACADEMY,

T OF MARCH, 1878.

PAYMENTS.	From Funds appropriated for Special Purposes. £	s.	d.	From Funds available for General Purposes. £	s.	d.	Total of each Class. £	s.	d.
For SCIENTIFIC AND LITERARY PURPOSES:—									
Polite Literature and Antiquity Objects,	.	.	.	.	.	.			
Scientific Reports,	130	0	0						
Library,	200	0	0	110	3	2			
Irish Scribe, &c.,	200	0	0	0	3	5			
„ (including Lithographing of Book of Leinster, and Printing Felire of Aengus,	200	0	0						
Museum,	200	0	0						
Treasure Trove	100	0	0						
Transactions and Proceedings,	200	0	0	187	16	7			
Opening the Academy in the evening,	152	7	4						
Book of Leinster,	83	4	0						
							1763	14	6
„ ESTABLISHMENT CHARGES:—									
Salaries,	.	.	.	409	0	0			
Wages and Liveries,	.	.	.	221	14	6			
Furniture and Repairs,	.	.	.	8	9	4			
Fuel,	.	.	.	34	3	0			
Insurance, Taxes, and Law,	.	.	.	8	2	6			
Stationery,	.	.	.	12	16	6			
Printing (Miscellaneous),	.	.	.	12	15	6			
Postage,	.	.	.	25	4	11			
Freights, Incidentals, and Contingencies,	.	.	.	18	0	4			
							750	6	7

„ INVESTMENTS (CAPITAL):—

	Stock Bought. £	s.	d.	Description.	Total Stock. £	s.	d.	Special £	s.	d.	Total £	s.	d.
Life Membership Compositions,	73	18	3	Consol. Stock,	2645	18	5	70	7	0			
Cunningham Bequest Interest, Balance,	81	8	11	New 3 per Cents,	2699	18	4	76	14	3			
Museum Catalogue,	2	10	11	Bk. of Ir. Stock,	42	16	9	8	7	3			
											155	8	6

	Special £	s.	d.	General £	s.	d.	Total £	s.	d.
„ TEA FUND Expenditure,	6	10	0	11	16	4	18	6	4
	£1627	9	10	1060	6	1	2687	15	11

LIST

OF THE

COUNCIL AND OFFICERS

AND

MEMBERS

OF THE

ROYAL IRISH ACADEMY;

DUBLIN,

1ST OF MAY, 1878.

DUBLIN:
ACADEMY HOUSE, 19, DAWSON STREET.
1878.

ROYAL IRISH ACADEMY.

President:

(*First elected*, 16*th of March*, 1877.)

SIR ROBERT KANE, M.D., LL.D., F.R.S., F.K. & Q.C.P.I.

The Council:

(*Elected* 16*th of March*, 1878.)

The Council consists of the Committees of Science and of Polite Literature and Antiquities.

Committee of Science (ELEVEN MEMBERS):

	Elected.		
(1)	Mar.,	1870	EDWARD PERCEVAL WRIGHT, M.D., F.L.S., F.R.C.S.I.
(2)	,,	1872	DAVID MOORE, PH.D., F.L.S.
(3)	,,	1872	JOHN CASEY, LL.D., F.R.S.
(4)	,,	1873	THOMAS HAYDEN, F.K. & Q.C.P.I., F.R.C.S.I.
(5)	,,	1874	REV. JOHN HEWITT JELLETT, B.D., S.F.T.C.D.
(6)	,,	1875	ALEXANDER CARTE, M.D., F.L.S., F.R.C.S.I.
(7)	,,	1875	WILLIAM ARCHER, F.R.S.
(8)	,,	1876	ROBERT STAWELL BALL, LL.D., F.R.S. (*Sec.*)
(9)	,,	1877	BINDON B. STONEY, M.A., C.E.
(10)	,,	1877	REV. SAMUEL HAUGHTON, M.D., D.C.L., F.R.S., F.T.C.D.
(11)	,,	1878	EDMUND W. DAVY, M.A., M.D

Committee of Polite Literature and Antiquities (TEN MEMBERS):

(12)	Mar.,	1859	JOHN KELLS INGRAM, LL.D., F.T.C.D.
(13)	,,	1867	WILLIAM JOHN O'DONNAVAN, LL.D.
(14)	,,	1869	ALEXANDER GEORGE RICHEY, LL.D., Q.C.
(15)	Dec.,	1869	JOHN RIBTON GARSTIN, M.A. & LL.B., F.S.A. (*Sec.*)
(16)	Mar.,	1871	VERY REV. WILLIAM REEVES, D.D., LL.D., M.B., Dean of Armagh.
(17)	,,	1873	REV. THADDEUS O'MAHONY, D.D.
(18)	,,	1875	ROBERT ATKINSON, LL.D.

Vice-Presidents:

(As nominated by the President, 16th of March, 1877: with the dates from which they have continuously been re-appointed.)

(1) SIR SAMUEL FERGUSON, LL.D., Q.C., (1870).
(2) THOMAS HAYDEN, F.K. & Q.C.P.I., F.R.C.S.I., (1877).
(3) ALEXANDER GEORGE RICHEY, LL.D., Q.C., (1877).
(4) REV. SAMUEL HAUGHTON, M.D., F.R.S., S.F.T.C.D., (1878).

Officers:

(Elected annually by the Academy; with date of first election.)

TREASURER, ...	JOHN RIBTON GARSTIN, M.A. & LL.B., F.S.A., (1871).
SECRETARY, ...	ROBERT STAWELL BALL, LL.D., F.R.S., (1874).
SECRETARY OF THE COUNCIL, ...	ROBERT ATKINSON, LL.D., (1878).
SECRETARY OF FOREIGN CORRESPONDENCE,	WILLIAM ARCHER, F.R.S., (1875).
LIBRARIAN, ...	JOHN T. GILBERT, F.S.A., (1878).

Clerk of the Academy, (elected annually by the Academy)	EDWARD CLIBBORN, ESQ., (1839).
Curator, Museum-Clerk, and Housekeeper, .	CAPT. ROBERT MACENIRY, (1872).
Irish Scribe, ...	MR. JOSEPH O'LONGAN, (1865).
Assistant Accountant, ...	MR. EDWARD SPENCER, M.A., (1873).
Library Clerk, ...	MR. J. J. MACSWEENEY, (1869).
Assistant in Library, ...	MR. R. J. O'MULRENIN, (1872).
Serjeant-at-Mace, ...	MR. J. J. MACSWEENEY, (1877).

Committees appointed by Council:

These Committees are composed of the Members of Council, to whose names the subjoined numbers are prefixed in the foregoing list:

MEMBERS OF THE ROYAL IRISH ACADEMY.

ORDINARY MEMBERS.

The sign * is prefixed to the names of Life Members.
The sign † indicates the Members who have not yet been formally admitted.
N.B.—The names of *Members whose addresses are not known* to the Secretary of the Academy, are printed in italics. He requests that they may be communicated to him.

Date of Election.	
1866. Jan. 8	Adams, Rev. Benjamin William, D.D. *The Rectory, Santry, Co. Dublin.*
1843. April 10	*Allman, George James, Esq., M.D. (Dub. and Oxon.), Pres. Lin. Soc., F.R.C.S.I., F.R.SS., Lond. & Edin. *Upper Phillimore Gardens, London, S.W.*
1871. June 12	*†Amherst, William Amhurst Tyssen-, Esq., D.L., F.S.A., M.R.S.L. *Didlington Hall, Brandon, Norfolk.*
1873. Jan. 13	Andrews, Arthur, Esq. *Newtown House, Blackrock, Co. Dublin.*
1839. Jan. 14	*Andrews, Thomas, Esq., M.D., LL.D. (Edin.), F.R.S., Hon. F.R.S. Ed., F.C.S., Vice-President, and Professor of Chemistry, Queen's College, Belfast. *Queen's College, Belfast.*
1842. Jan. 10	*Andrews, William, Esq., F.R.G.S.I. *Ashton, The Hill, Monkstown, Co. Dublin.*
1828. April 28	*Apjohn, James, Esq., M.D., F.R.S., F. and Hon. F., K. & Q.C.P.I., F.C.S., Professor of Mineralogy and of Applied Chemistry, Dublin Univ. *South Hill, Blackrock, Co. Dublin.*
1870. Jan. 10	*Archer, William, Esq., F.R.S., Secretary of Foreign Correspondence. *St. Brendan's, Grosvenor-road, E., Rathmines, Co. Dublin.*
1815. Mar. 16	*Ashburner, John, Esq., M.D., M.R.C. Phys. Lon. 7, *Hyde Park-place, London.*
1875. Jan. 11	Atkinson, Robert, Esq., LL.D., Professor of Romance Languages, Univ. Dub., Secretary of Council of the Academy. 20, *Garville-avenue, Rathgar, Co. Dublin.*
1872. April 8	Baily, William Hellier, Esq., F.L.S., F,G.S., Demonstrator in Palæontology, R.C.Sci.I. *Apsley Lodge,* 92, *Rathgar-road, Co. Dublin;* 14 *Hume-street, Dublin.*

Date of Election.	
1840. April 13	*Ball, John, Esq., M.A., F.R.S., F.L.S. 10, *Southwell Gardens, South Kensington, London, S.W.*
1870. Jan. 10	Ball, Robert Stawell, Esq., LL.D., F.R.S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland, Secretary of the Academy. *The Observatory, Dunsink, Co. Dublin.*
1842. Jan. 10	*Banks, John T., Esq., M.D., F.K. & Q.C.P.I. 10, *Merrion-square, East, Dublin.*
1851. April 14	*Barker, John, Esq., M.D., F.R.C.S.I., F.R.G.S.I. 48, *Waterloo-road, Dublin.*
1868. Jan. 13	*Barker, W. Oliver, Esq., M.D., M.R.C.S.E. 6, *Gardiner's-row, Dublin.*
1874. May 11	Barrett, William F., Esq., F.R.C.S.E., Professor of Physics, Royal College of Science. 9, *Montpelier-parade, Monkstown, Co. Dublin.*
1866. May 14	Barrington, Sir John, D.L. *St. Anne's, Killiney, Co. Dublin.*
1865. Jan. 9	*Beauchamp, Robert Henry, Esq. 116, *Grafton-street, Dublin.*
1863. April 27	*Belmore, Right Hon. Somerset-Richard, Earl of, M.A., D.L., K.C.M.G. *Castle Coole, Enniskillen.*
1866. June 11	Bennett, Edward Hallaran, Esq., M.D., M.Ch., F.R.C.S.I., F.R.G.S.I., Professor of Surgery in the University of Dublin. 26, *Fitzwilliam-street, Lower, Dublin.*
1825. Nov. 30	*Benson, Charles, Esq., M.A., M.B., F.R.C.S.I. 42, *Fitzwilliam-square, (West), Dublin.*
1851. June 8	†Beresford, Right Hon. and Most Rev. Marcus G., D.D., D.C.L., Lord Archbishop of Armagh, Primate of all Ireland. *The Palace, Armagh*
1846. April 13	*Bevan, Philip, Esq., M.D. (Dub.), Prof. of Anatomy and Fellow R.C.S.I. 52, *Fitzwilliam-square, (West), Dublin.*
1843. Jan. 9	*Blacker, Stewart, Esq., M.A., J.P. *Carrick Blacker, Portadown.*
1876. Jan. 11	*Blake, John A., Esq., Inspector of Fisheries. 12, *Ely-place, Dublin.*
1871. Jan. 9	Bourke, Very Rev. (Canon) Ulick J., President of St. Jarlath's College, Tuam. *St. Jarlath's, Tuam.*
1873. April 14	†Boyd, Michael A., Esq., F.R.C.S.I., L.K. & Q.C.P.I. 90, *George's-street, Upper, Kingstown, Co. Dublin.*
1854. April 10	*Brady, Cheyne, Esq. *(Abroad.)*

Date of Election.	
1851. Jan. 13	*Browne, Robert Clayton, Esq., M.A., D.L. *Browne's Hill, Carlow.*
1874. Feb. 9	†Burden, Henry, Esq., M.A., M.D., M.R.C.S.E. 9, *College-square, North, Belfast.*
1854. April 10	Burke, Sir John Bernard (Ulster), LL.D., C.B. *Tullamaine Villa, Leeson-street, Upper, Dublin.*
1878. Feb. 11	†Burton, Charles E., A.B., F.R.A.S. *Observatory, Dunsink, Co. Dublin.*
1855. Jan. 8	*Butcher, Richard G., Esq., M.D., F.R.C.S.I., M.R.C.S.E. 19, *Fitzwilliam-street, Lower, Dublin.*
1866. April 9	Byrne, John A., Esq., B.A., M.B. (Dub.) 37, *Westland-row, Dublin.*
1876. May 8	Byrne, William H., Esq., C.E. *Largo House, Rathmines, Co. Dublin.*
1862. April 14	Campbell, John, Esq., M.D., Professor of Chemistry, C.U.I. 36, *Leinster-road, Rathmines, Co. Dublin.*
1873. May 12	†Carlingford, Right Hon. Chichester, Baron, D.L., Lord Lieutenant of Essex. *Red House, Ardee; 7, Carlton Gardens, London, S.W.*
1838. Feb. 12	*Carson, Rev. Joseph, D.D., S.F.T.C.D., F.R.G.S.I. 18, *Fitzwilliam-place, Dublin.*
1855. Feb. 12	Carte, Alexander, Esq., M.D., F.R.C.S.I., F.R.G.S.I., Director of the Royal Dublin Society's Museum of Natural History. 14, *Northbrook-road, Dublin.*
1876. Jan. 11	†Carton, Richard Paul, Esq., Q.C. 35, *Rutland-square (West), Dublin.*
1866. May 14	Casey, John, Esq., LL.D., F.R.S., Professor of Higher Mathematics and Mathematical Physics, C.U.I. *Iona-terrace, Circular-road (South), Dublin.*
1873. Jan. 13	†Castletown of Upper Ossory, Right Hon. John-Wilson, Baron, Lieutenant of the Queen's County. *Lisduff, Errill, Templemore.*
1862. Jan. 13	*†Cather, Rev. Robert G., LL.D. *Nutty Hagg, Wandsworth Common, London, S.W.*
1843. Jan. 8	*Cather, Thomas, Esq., J.P. *Newtownlimavady.*
1842. June 13	*Chapman, Sir Benjamin J., Bart., D.L. *Killua Castle, Clonmellon.*
1864. Jan. 11	Charlemont, Right Hon. James-Molyneux, Earl of, K.P., Lieutenant of the County Tyrone. *Roxborough Castle, Moy, Co. Armagh.*
1876. April 10	*Clarke, Francis E., M.A., M.D., L.K.Q.C.P.I., M.R.C.S.E. 28, *Lawrence-street, Drogheda.*
1857. April 13	*†Cleland, James, Esq., J.P. *Tobar Mhuire, Crossgar*

Date of Election.	
1841. Jan. 11	*†Clermont, Right Hon. Thomas, Baron, D.L. ***Ravensdale Park, Newry.***
1867. May 13	*Close, Rev. Maxwell H., M.A., F.R.G.S.I. 40 ***Baggot-street, Lower, Dublin.***
1835. Nov. 30	**Cole*, Owen Blayney, Esq., D.L.
1874. June 8	Collins, Edward Wolfenden, Esq., M.D. 33, ***Baggot-street, Lower, Dublin.***
1866. April 9	†Cooper, Lieut. Col. Edward H., D.L. ***Markree Castle, Collooney.***
1856. April 14	Copland, Charles, Esq. ***Royal Bank, Foster-place, Dublin; 7, Longford-terrace, Monkstown, Co. Dublin.***
1825. Nov. 30	*Corballis, John R., Esq., LL.D., Q.C. ***Rosemount, Roebuck, Clonskeagh, Co. Dublin.***
1847. Jan. 11	*Corrigan, Sir Dominic J., Bart., M.D., F.K.&Q.C.P.I., For. Corr. Mem. Academie de Medecine, Paris. 4, ***Merrion-square, West, Dublin.***
1864. May 9	†Cotton, Charles Philip, Esq., B.A., C.E., F.R.G.S.I. 11, ***Pembroke-street, Lower, Dublin.***
1846. Jan. 12	Cotton, Rev. Henry, LL.D., D.C.L. (late Archdeacon of Cashel.) ***Lismore.***
1876. Apr. 10	Cox, Michael Francis, Esq., M.A., L.R.C.S.I. ***Sligo.***
1857. Aug. 24	*Crofton, Denis, Esq., B.A. 8, ***Mountjoy-square, (North), Dublin.***
1867. June 24	*†Crofton, Henry Morgan E, Esq., F.R.A.S., J.P. ***Inchinappa, Ashford, Co. Wicklow.***
1866. June 11	Cruise, Francis R., Esq., M.D., F.K. & Q.C.P.I., M.R.C.S.E. 3, ***Merrion-square, West, Dublin.***
1870. Apr. 11	Cruise, Richard Joseph, Esq., F.R.G.S.I., Geological Survey of Ireland. ***Boyle, Co. Roscommon;*** 14, ***Hume-street, Dublin.***
1874. June 8	Cryan, Robert, Esq., M.D. 54, ***Rutland-square, (West), Dublin.***
1876. Nov. 13	*†Dalway, Marriott R., Esq., M.P. ***Bella Hill, Carrickfergus.***
1853. April 11	*Davies, Francis Robert, Esq., K.J.J. ***Hawthorn, Blackrock, Co. Dublin.***
1855. May 14	*Davy, Edmund W., Esq., M.A., M.D., Prof. of Med. Jurisprudence, R.C.S.I. ***Fortfield Terrace, Templeogue, Co. Dublin.***
1846. April 13	*D'Arcy, Matthew P., Esq., M.A., D.L. 6, ***Merrion-square, East, Dublin.***

Date of Election.	
1846. Jan. 12	*Deasy, Right Hon. Rickard, LL.D., Third Baron of the Exchequer. *Carysfort House, Blackrock, Co. Dublin.*
1851. June 9	*†De la Ponce, Mons. Amadie. *Paris.*
1860. Jan. 9	*Dickson, Rev. Benjamin, D.D., F.T.C.D. 3, *Kildare-place, Dublin.*
1876. Feb. 14	Dillon, William, Esq. 2, *George's-street, Great, North, Dublin.*
1876. Jan. 11	*Doberck, William, Esq., Ph.D. *Observatory, Markree, Collooney.*
1847. Jan. 11	*†Dobbin, Leonard, Esq. 27, *Gardiner's-place, Dublin.*
1851. Jan. 13	*Dobbin, Rev. Orlando T., LL.D. *Sutton, Co. Dublin.*
1856. Feb. 11	Downing, Samuel, Esq., C.E., LL.D., F.R.G.S.I., Professor of Civil Engineering, Dublin Univ. 4, *The Hill, Monkstown, Co. Dublin.*
1876. June 26	†Draper, Harry N. Esq., F.C.S. *Palmerston-park, Rathmines, Co. Dublin.*
1873. Jan. 13	Drew, Thomas, Esq., R.H.A., F.R.I.A.I. 6, *St. Stephen's-green, (North), Dublin.*
1843. Jan. 9	*Drury, William Vallancey, Esq., M.D. 7, *Harley-street, Cavendish-square, London, W.*
1861. Feb. 11	Duncan, James Foulis, Esq., M.D., F.K. & Q.C.P.I. 8, *Merrion-street, Upper, Dublin.*
1873. Jan. 13	Durham, James Samuel William, Esq., F.R.G.S.I. *Rosenthal, Torquay, South Devon.*
1843. Dec. 11	*†Eiffe, James S., Esq., F.R.Ast.S. *The Laurels, Yiewsley, West Drayton, England.*
1867. Feb. 11	Ellis, George, Esq., M.B., F.R.C.S.I. 91, *Leeson-street, Lower, Dublin.*
1841. April 12	*Emly, Right Hon. William, Baron, Lieutenant of the County Limerick. *Tervoe, Limerick; Athenæum Club, London, S.W.*
1846. Jan. 12	*Enniskillen, Right. Hon. William-Willoughby, Earl of, LL.D., D.C.L., D.L., F.R.S., F.R.G.S.I., one of the Trustees of the Hunterian Museum, R.C.S., London. *Florence Court, Co. Fermanagh;* 65, *Eaton-place, London, S.W.*
1867. April 8	*Farrell, Thomas A., Esq., M.A. 3, *Merrion-square, East, Dublin.*
1834. Mar. 15	*Ferguson, Samuel, Esq., LL.D., Q.C., a Vice-President of the Academy. 20, *George's-street, Great, North, Dublin.*

Date of Election.	
1857. Aug. 24	Fitzgerald, Right Rev. William, D.D., Lord Bishop of Killaloe, &c. *Clarisford House, Killaloe.*
1870. May 23	†FitzGibbon, Abraham, Esq., M.I.C.E. Lond. *The Rookery, Great Stanmore, Middlesex.*
1841. April 12	*Fitzgibbon, Gerald, Esq., M.A., Master in Chancery. 10, *Merrion-square, North, Dublin.*
1875. Jan. 11	Fitzpatrick, William John, Esq., J.P., LL.D. 75, *Pembroke-road, Dublin.*
1860. Jan. 9	Foley, William, Esq., M.D., M.R.C.S.E. *Kilrush.*
1874. May 11	Foot, Arthur Wynne, Esq., M.D., F.K.Q.C.P.I., F.R.G.S.I. 49, *Leeson-street, Lower, Dublin.*
1874. Feb. 9	†Foster, Rev. Nicholas. *Ballymacelligott Rectory, Tralee.*
1876. Feb. 14	Fottrell, George, Esq. 8, *George's-street, Great, North, Dublin.*
1838. Nov. 12	**Frazer*, George A., Esq., Captain R.N.
1866. May 14	Frazer, William, Esq., F.R.C.S.I., F.R.G.S.I. 20, *Harcourt-street, Dublin.*
1865. April 10	†Freeland, John, Esq., M.D. *Antigua, West Indies.*
1847. May 10	*Freke, Henry, Esq., M.D. (Dub.), F.K.&Q.C.P.I. 68, *Mount-street, Lower, Dublin.*
1873. April 14	*†Frost, James, Esq., J.P. *Ballymorris, Cratloe, Co. Clare.*
1875. June 14	Furlong, Nicholas, Esq., M.D. *Symington, Enniscorthy.*
1859. Jan. 10	Gages, Alphonse, Esq., Chev. L.H., F.R.G.S.I. *Royal College of Science,* 51 *St. Stephen's-green, (East), Dublin.*
1845. April 14	*Galbraith, Rev. Joseph Allen, M.A., F.T.C.D., F.R.G.S.I. 8, *Trinity College, Dublin.*
1866. June 11	†Gallwey, Thomas, Esq., J.P. 42, *Harcourt-street, Dublin.*
1864. Jan. 11	Garnett, George Charles, Esq., M.A. 5, *Mountjoy-square, (North), Dublin.*
1863. Feb. 9	*Garstin, John Ribton, Esq., M.A., LL.B., F.S.A., F.R. Hist. Soc., Hon. F.R.I.A.I., J.P., Treasurer of the Academy. *Green-hill, Killiney, Co. Dublin.*
1851. Jan. 13	Gibson, James, Esq., M.A., Q.C. 35, *Mountjoy-square, (South), Dublin.*
1855. April 9	*Gilbert, John Thomas, Esq., F.S.A., R.H.A., Librarian of the Academy. *Villa Nova, Blackrock, Co. Dublin.*
1876. May 8	Gillespie, William, Esq. *Racefield House, Kingstown. Co. Dublin.*
1875. April 12	*†Gore, J. E., Esq., C.E., A.I.C.E., F.R.A.S., F.R.G.S.I. *Dromard, Ballisodare, Co. Sligo.*

Date of Election.	
1848. June 12	*Graham, Andrew, Esq. *Observatory, Cambridge.*
1848. April 10	*Graham, Rev. William. *Dresden.*
1876. April 10	†Grainger, Rev. John, D.D. *Broughshane, Co. Antrim.*
1863. April 13	†Granard, Right Hon. George-Arthur-Hastings, Earl of, K.P. *Castle Forbes, Co. Longford.*
1837. April 24	*Graves, Right Rev. Charles, D.D., Lord Bishop of Limerick, &c. *The Palace, Henry-street, Limerick.*
1874. Feb. 9	Gray, William, Esq. 6, *Mount-Charles, Belfast.*
1867. April 8	Green, James S., Esq. Q.C. 83, *Leeson-street, Lower, Dublin.*
1872. April 8	†Greene, John Ball, Esq., C.E., F.R.G.S.I., Commissioner of Valuation. 6, *Ely-place, Dublin.*
1819. April 26	*Griffith, Sir Richard, Bart., LL.D., F.R.S.Ed., F.G.S., V.P.R.G.S.I. 2, *Fitzwilliam-place, Dublin.*
1842. Jan. 10	*Grimshaw, Wrigley, Esq., F.R.C.S.I. 4, *Brighton-terrace, Bray.*
1857. June 8	*Griott, Daniel G., Esq., M.A. 9, *Henrietta-street, Dublin.*
1839. Jan. 14	*Grubb, Thomas, Esq., F.R.S. 141, *Leinster-road, Rathmines, Co. Dublin.*
1870. April 11	†Guinness, Sir Arthur E., Bart., M.A., M.P., D.L. 18, *Leeson-street, Lower; St. Anne's, Clontarf, Co. Dublin.*
1873, Dec. 8	*Guinness, Edward Cecil, Esq. M.A., D.L. 80, *St. Stephen's-green (South), Dublin.*
1836. April 25	*Hamilton, Charles William, Esq., J.P. 40, *Dominick-street, Lower, Dublin.*
1875. Jan. 11	Hamilton, Edward, M.D., F.R.C.S.I. 120, *St. Stephen's-green, (West), Dublin.*
1867. April 8	*Hanagan, Anthony, Esq. *Luckington, Dalkey, Co. Dublin.*
1847. Jan. 11	Hancock, William Neilson, Esq., LL.D. 64B, *Gardiner-street, Upper, Dublin.*
1850. April 8	*Hardinge, William Henry, Esq. 20, *Clarinda Park, East, Kingstown, Co. Dublin.*
1837. Feb. 13	*Hart, Andrew Searle, Esq., LL.D., S.F.T.C.D. 71, *St. Stephen's-green, (South); Trinity College, Dublin.*
1874. Dec. 14	*Harvey, Reuben Joshua, Esq., M.D. 7, *Merrion-street, (Upper), Dublin.*
1861. May 13	Hatchell, John, Esq., M.A., J.P. 12, *Merrion-square, South, Dublin.*
1857. Aug. 24	Hayden, Thomas, Esq., F.K.&Q.C.P.I., Prof. of

Date of Election.	
1845. Feb. 24	*Haughton, Rev. Samuel, M.A., M.D., D.C.L. (Oxon.), F.R.S., F.G.S., F.R.G.S.I., F.K. & Q.C.P.I., Hon. F.R.C.S.I., F.T.C.D., Professor of Geology in the University of Dublin, a Vice-President of the Academy. 31, *Baggot-street, Upper, Dublin.*
1852. April 12	*Head, Henry H., Esq., M.D., F.K. & Q.C.P.I., Ex-F.R.C.S.I., F.R.G.S.I. 7, *Fitzwilliam-square (East), Dublin.*
1870. April 11	†Heily, John Vickers, Esq., M.D. *Lisaduran Cottage, Rushworth, Melbourne, Victoria.*
1840. June 8	*Hemans, George Willoughby, Esq., C.E., F.G.S. 1, *Westminster Chambers, Victoria-street, London, S.W.;* 17, *Gloucester-street, Upper, Dublin.*
1851. Jan. 13	*Hennessy, Henry, Esq., F.R.S., Professor of Applied Mathematics and Mechanics in the Royal College of Science for Ireland, St. Stephen's-green, Dublin. *Mount Eagle, Sandyford, Co. Dublin.*
1865. Feb. 13	*Hennessy, William Maunsell, Esq. 8, *Islington-avenue, Kingstown, Co. Dublin.*
1871. Feb. 13	†Henry, Rev. P. Shuldham, D.D., President Q.C., Belfast. *Queen's College, Belfast.*
1873. Jan. 13	Hickie, James Francis, Lieut.-Col. (retired), J.P. *Slevoir, Roscrea, Co. Tipperary.*
1831. Mar. 16	*Hill, Lord George Augusta. *Ballyare House, Rathmelton, Letterkenny, Co. Donegal.*
1867. Feb. 11	†Hill, John, Esq., C.E., F.R.G.S.I. *County Surveyor's Office, Ennis.*
1875. Jan. 11	*†Hill, Arthur, Esq., B.E., A.R.I.B.A. 22, *George's-street, Cork.*
1847. April 12	*Hone, Nathaniel, Esq., M.A., F.R.G.S.I., J.P. *St. Doulough's, Co. Dublin.*
1861. April 8	Hudson, Alfred, Esq., M.D., F.K. & Q.C.P.I., F.R.G.S.I. 2, *Merrion-square, North, Dublin.*
1824. Feb. 28	*Hudson, Henry, Esq., M.D., F.K. & Q.C.P.I. *Glenville, Fermoy.*
1875. June 11	†Hume, Rev. Abraham, (Canon), D.C.L., LL.D. (Hon.); F.S.A.; F.R.S.N.A. (Copenhagen); Corr. F.S.A. Scot.; Hon. F.S.A. Newcastle; Member of the Philological and Eng. Dialect Societies; Ex-President Historic Soc. of Lanc. and Cheshire. *All Souls' Vicarage, Liverpool.*

Date of Election.	
1841. April 12	*Jellett, Rev. John Hewitt, B.D., S.F.T.C.D., F.R.G.S.I. 64, *Leeson-street, Lower, Dublin.*
1842. June 13	*Jennings, Francis M., Esq., F.G.S., F.R.G.S.I. *Brown-street, Cork.*
1867. April 8	Jephson, Robert H., Esq. *Mount Erroll, Donnybrook, Co. Dublin.*
1863. Jan. 12	Joyce, Patrick Weston, Esq., LL.D. 7, *St. Edward's-terrace, Garville-avenue, Rathgar.*
1870. Dec. 12	*†Joyce, Robert D., Esq., M.D. 21, *Bowdoin-street, Boston, Mass., U.S., America.*
1831. Nov. 30	*Kane, Sir Robert, M.D., LL.D., F.K. & Q.C.P.I., F.R.S., F.R.G.S.I., F.C.S., PRESIDENT of the Academy. 21, *Raglan-road; Fortlands, Killiney Co. Dublin.*
1873. Dec. 8	*Kane, Robert Romney, Esq., M.A. 76, *Harcourt-street, Dublin.*
1865. April 10	Kane, William Francis De Vismes, Esq., M.A., J.P. *Drumreaske House, Monaghan.*
1869. June 14	Kavanagh, Very Rev. James B., D.D. *St. Patrick's College, Carlow.*
1870. June 13	*Keane, John P., Esq., C.E., Engineer, Public Works Department, Bengal. *Calcutta.*
1867. Feb. 11	Keane, Marcus, Esq., J.P. *Beech Park, Ennis.*
1864. Nov. 14	*Keenan, Patrick J., Esq., C.B., Resident Commissioner, Board of National Education, Ireland. *Delville, Glasnevin, Co. Dublin.*
1876. May 8	Kelly, James Edward, Esq., M.D. 2, *Gardiner's-row, Dublin.*
1870. May 23	*Kelly, John, Esq., L.M. (Dub.). *University College Hospital, Calcutta.*
1869. Nov. 8	†Kelso, John Johnston, Esq., M.D., M. Ch. *Lisburn.*
1846. April 13	*Kennedy, James Birch, Esq., J.P. *Cara, by Killarney.*
1874. May 11	†Kidd, Abraham, Esq., M.D. *Ballymena.*
1876. Feb. 14	†*Kildare, Most Noble Gerald, Marquess of. *Carton, Maynooth.*
1875. June 14	†Kilgariff, Malachy J., Esq., F.R.C.S.I. 30, *Harcourt-street, Dublin.*
1866. April 9	*Kinahan, Edward Hudson, Esq., D.L., J.P. 11, *Merrion-square, North, Dublin.*
1868. Jan. 13	Kinahan, George Henry, Esq., F.R.G.S.I. *Ovoca, Co. Wicklow; Geological Survey Office,* 14, *Hume-street, Dublin.*

Date of Election.

1837. Feb. 13	**Knox*, George J., Esq.
1835. Nov 30.	*Kyle, William Cotter, Esq., LL.D. 8, *Clare-st., Dublin.*
1864. April 11	*Lalor, John J., Esq., F.R.G.S.I. *City Hall, Cork-hill, Dublin.*
1875. May 10	†Lane, Alexander, Esq., M.D. *Ballymoney.*
1833. Nov. 30	*Larcom, Right Hon. Sir Thomas Aiskew, Bart., Major-General, K.C.B., R.E., LL.D., F.R.S., F.R.G.S.I., an Honorary Member of the Academy. *Heathfield, Fareham, Hants.*
1864. Jan. 11	LaTouche, J. J. Digges, Esq., M.A. 1, *Ely-place, Upper, Dublin.*
1836. Jan. 25	*LaTouche, William Digges, Esq., M.A., D.L. 34, *St. Stephen's-green, (North), Dublin.*
1857. May 11	*Lawson, Right Hon. James A., LL.D., Justice of the Court of Common Pleas. 27, *Fitzwilliam-street, Upper, Dublin.*
1857. April 13	*Leach, Lieut.-Colonel George A., R.E. 3, *St. James's-square, London, S.W.*
1839. May 13	*†Leader, Nicholas P., Esq., J.P. *Dromagh Castle, Kanturk.*
1852 May 10	Leared, Arthur, Esq., M.D. (Dub.), F.R.C.P. Lond., and Physician to the Great Northern Hospital. 12, *Old Burlington-street, London, W.*
1845. Feb. 10	*LeFanu, William R., Esq., C.E. *Summerhill, Enniskerry, Co. Wicklow.*
1846. May 11	*Lefroy, George, Esq. *(Abroad.)*
1844. April 8	*†Leinster, His Grace Charles-William, Duke of, Chancellor of the Queen's University in Ireland, and President of the Royal Dublin Society. *Carton, Maynooth.*
1828. April 28	*†Lenigan, James, Esq., M.A., D.L. *Castle Fogarty, Thurles.*
1869. April 12	*Lenihan, Maurice, Esq., J.P. *Limerick.*
1853. April 11	Lentaigne, John, Esq., C.B.. M.B., J.P., F.R.G.S.I. 1, *Denmark-street, Great, Dublin.*
1870. June 13	Leonard, Hugh, Esq., F.G.S., F.R.G.S.I. *Geological Survey of Ireland,* 14, *Hume-street, Dublin.*
1868. April 27	*Little, James, Esq., M.D., L.R.C.S.I., F.K.& Q.C.P.I. 24, *Baggot-street, Lower, Dublin.*
1877. May 14	†Lloyd, Christopher, Esq., M.D., Surgeon, H.M's. Madras Army. 31*st Madras Light Infantry, Rnipore, India.*
1832. Feb. 27	*Lloyd, Rev. Humphrey, D.D., D.C.L. (Oxon.), F.R.SS.

Date of Election.	
1876. Jan. 11	Lloyd, Joseph Henry, Esq., M.A., Ph. D., F.R.S.L., F.S.A., M. Phil. Soc. *Chalgrove, Circular-road, South, Dublin.*
1846. Jan. 12	*Lloyd, William T., Esq., M.D. *London.*
1875. April 12	Lombard, James F., Esq., J.P. *South-hill, Rathmines, Co. Dublin.*
1845. Feb. 10	*Longfield, Rev. George, D.D., F.T.C.D. 1, *Earls-fort-terrace, Dublin.*
1838. Feb. 12	*†Longfield, Right Hon. Mountifort, LL.D. (late Judge in the Landed Estates' Court). 47, *Fitzwilliam-square, (West), Dublin.*
1878. Feb. 11	†Lowry, Robert William, Esq., B.A. (Oxon.) D.L., J.P. *Pomeroy House, Dungannon, Co. Tyrone.*
1868. Jan. 13	Lyne, Robert Edwin, Esq. *Sandymount, Co. Dublin.*
1851. May 12	*Lyons, Robert D., Esq., M.B., F.K. & Q.C.P.I., Prof. of Medicine, C.U.I. 8, *Merrion-square, West, Dublin.*
1873. April 14	Macalister, Alexander, Esq., M D., L.R.C.S.I., L.K. & Q.C.P.I., F.R.G.S.I., Professor of Comparative Anatomy and Zoology in the University of Dublin. 15. *Palmerston-road, Upper Rathmines, Co. Dublin.*
1871. Feb. 13	*Macartney, J. W. Ellison, Esq., M.P., J.P. *The Palace, Clogher.*
1857. April 13	Mac Carthy, Denis Florence, Esq. 21, *Notting-hill Terrace, London, W.*
1853. April 11	*McCarthy, James Joseph, Esq., R.H.A. *Charleston House, Rathmines, Co. Dublin.*
1875. Jan. 11	†Mac Carthy, John G., Esq., M.P. *River View, Montenotte, Cork.*
1874. Feb. 9	McClure, Rev. Edmund, M.A. 67, *Lincoln's-Inn Fields, London, W.C.*
1873. Jan. 13	*McCready, Rev. Christopher, M.A. 56, *High-street, Dublin.*
1864. April 11	*McDonnell, Alexander, Esq., M.A., C.E., F.R.G.S.I. *St. John's, Island-bridge, Co. Dublin.*
1825. Feb. 24	**Macdonnell*, James S., Esq., C.E.
1827. Mar. 16	*Mac Donnell, John, Esq., M.D., F.R.C.S.I., F.R.G.S.I. 32, *Fitzwilliam-street, Upper, Dublin.*
1857. Feb. 9	*McDonnell, Robert, Esq., M.D., President and Fellow R.C.S.I., F.R.S. 14, *Pembroke-street, Lower, Dublin.*
1865. April 10	†Mac Donnell, Lieut.-Col. William Edward Arm-

Date of Election.	
1876. April 10	McIlwaine, Rev. William, D.D. *Ulster Villas, Belfast.*
1871. April 10	Macnaghten, Colonel Sir Francis Edmund, Bart. (Late 8th Hussars). *Dundarave, Bushmills, Co. Antrim.*
1831. Feb. 28	**Mac Neill,* Sir John, LL.D., F.R.S., F.R.A.S.
1874. April 13	McSwiney, Stephen Myles, Esq., M.D. 1, *Hume-street, Dublin.*
1846. Feb. 23	*Madden, Richard R., Esq., F.R.C.S. Eng. 1, *Vernon-terrace, Booterstown-avenue, Booterstown, Co. Dublin.*
1864. June 13	Madden, Thomas More, Esq., M.D., L.K.Q.C.P.I., M.R.C.S.E., Examiner in Midwifery, etc., Q.U.I. 33, *Merrion-square, South, Dublin.*
1870. Jan. 10	Mahaffy, Rev. John Pentland, M.A., F.T.C.D. 38, *George's-street, Great, North, Dublin.*
1874. Feb. 9	Malet, John Christian, Esq., M.A. *Trinity College, Dublin.*
1832. Oct. 22	*Mallet, Robert, Esq., M.A., M. Eng., Ph. D., M.I.C.E., F.R.S., F.G.S., F.R.G.S.I. 16, *The Grove, Clapham-road, London, S.*
1865. April 10	*†Malone, Rev. Silvester, P.P., F.R.H.A.A.I. *Six-milebridge.*
1859. Jan. 10	*Manchester, His Grace William-Drogo, Duke of. 1, *Great Stanhope-street, London; Kimbolton Castle, St. Neot's, Hunts; The Castle, Tanderagee.*
1828. Mar. 15	*Martin, Ven. John Charles, D.D., Archdeacon of Kilmore. *Killeshandra.*
1871. Jan. 9	Maunsell, George Woods, Esq., M.A., D.L., V.P. R.D.S. 10, *Merrion-square, South, Dublin.*
1876. April 10	†Meyers, Walter, Esq. 2, *Richard-street, Spencer-street, Birmingham.*
1861. Jan. 14	†Monck, Right Hon. Charles-Stanley, Viscount, G.C.M.G., Lieutenant of Dublin City and County. *Charleville, Bray, Co. Wicklow.*
1858. Jan. 11	**Montgomery,* Howard B., Esq., M.D.
1860. Jan. 9	Moore, Alexander G. Montgomery, Lieut.-Colonel, 4th Hussars. *India.*
1845. June 23	*Moore, David, Esq., Ph. D., F.L.S., Director of the Botanical Gardens, Glasnevin. *Glasnevin, Co. Dublin.*
1861. Jan. 14	Moore, James, Esq., M.D., M.R.C.S.E. 7, *Chichester-street, Belfast.*
1869. Feb. 8	*Moran, Most Rev. Patrick F., D.D., Bishop of Ossory. *St. Kyran's College, Kilkenny.*

Date of Election.	
1840 Feb. 10	*Napier, Right Hon. Sir Joseph, Bart., D.C.L., LL.D., Vice-Chancellor of Dublin University. 4, *Merrion-square, South, Dublin.*
1844. June 8	*Neville, John, Esq., C.E., F.R.G.S.I. *Roden-place, Dundalk.*
1854. May 8	Neville, Parke, Esq., C.E. 58, *Pembroke-road, Dublin.*
1872. June 24	Nolan, Francis, Esq., A.R.I.A.I. *Ardeevin, Glenageary, Kingstown, Co. Dublin.*
1873. Jan. 13	Nolan, Joseph, Esq., F.R.G.S.I., Geological Survey of Ireland. 14, *Hume-street, Dublin.*
1846. Jan. 12	*†Nugent, Arthur R., Esq. *(Portaferry, Co. Down).*
1869. June 14	*O'Brien, James H., Esq. *St. Lorcan's, Howth, Co. Dublin.*
1869. June 14	O'Callaghan, John Cornelius, Esq. 1, *Rutland-street, Upper, Dublin.*
1875. Jan. 11	O'Callaghan, J. J., Esq., F.R.I.A.I. 31 *Harcourt-street, Dublin.*
1867. June 10	O'Conor Don, The, D.L., M.P. *Clonalis, Castlerea, Co. Roscommon.*
1833. May 27	*O'Dell, Edward, Esq., J.P. *Carriglea, Dungarvan.*
1867. Jan. 14	O'Donel, Charles J. Esq., J.P. 47, *Leeson-street, Lower, Dublin.*
1865. Apr. 10	O'Donnavan, William J., Esq., LL.D. *University Club,* 17, *St. Stephen's-green, (North), Dublin;* 54, *Kenilworth-square, Rathgar, Co. Dublin.*
1869. Apr. 12	†O'Ferrall, Ambrose More, Esq. *Kildare-street Club, Dublin.*
1866. June 8	*O'Grady, Edward S., Esq., B.A., M.B., M. Ch., F.R.C.S.I. 105, *St. Stephen's-green, (South), Dublin.*
1867. May 13	†O'Grady, Standish H., Esq. *Polmont Park, Polmont, Scotland.*
1866. June 25	O'Hagan, John, Esq., M.A., Q.C. 22, *Fitzwilliam-street, Upper, Dublin.*
1857. June 8	O'Hagan, Right Hon. Thomas, Baron. 34, *Rutland-square, (West), Dublin.*
1869. Apr. 12	O'Hanlon, Rev. John. *Presbytery, Exchange-street, Lower, Dublin.*
1878. Feb. 11	†O'Hanlon, Michael, Esq., L.K. & Q.C.P.I. *Castlecomer, Co. Kilkenny.*
1866. Jan. 8	O'Kelly, Joseph, Esq., M.A., F.R.G.S.I., Geological Survey of Ireland. 7, *Warwick-terrace, Leeson Park, Dublin;* 14, *Hume-street, Dublin.*

Date of Election.	
1844. June 10	*Oldham, Thomas, Esq., LL.D., F.R.S., F.G.S., Hon. F.R.G.S.I., Superintendent of the Geological Survey of India. *Calcutta.*
1871. Apr. 10	O'Looney, Brian, Esq., F.R.H.S., Professor of Irish Language, Literature, and Archæology to the Catholic University of Ireland, 85, St. Stephen's-green (South). *Grove-villa House, Crumlin, Co. Dublin.*
1861. June 10	*O'Mahony, Rev. Thaddeus, D.D., Prof. of Irish in Dublin University. 37, *Trinity College, Dublin.*
1870. Jan. 10	O'Reilly, Joseph P., Esq., C.E., Prof. of Mining and Mineralogy, Royal Coll. of Science, Dublin. 58, *Park-avenue, Sandymount, Co. Dublin.*
1866. June 11	O'Rourke, Rev. John. *St. Mary's, Maynooth.*
1838. Dec. 10	*Orpen, John Herbert, Esq., LL.D. 58, *Stephen's-green, (East), Dublin.*
1870. Feb. 14	O'Shaughnessy, Mark S., Esq., Regius Prof. of English Law, Queen's College, Cork, and one of the Examiners, Q.U.I. 19, *Gardiner's-place, Dublin.*
1866. Jan. 8	O'Sullivan, Daniel, Esq., Ph. D. 9, *Eden-park, Sandycove, Kingstown, Co. Dublin.*
1839. June 10	*Parker, Alexander, Esq., J.P. 46, *Upper Rathmines, Co. Dublin.*
1873. Feb. 10.	Patterson, William Hugh, Esq. *Dundela, Strandtown, Belfast.*
1847. Feb. 8	*†Pereira [elected as Tibbs], Rev. Henry Wall, M.A., F.S.A. Scot., &c. *Donnington Lodge, Iffley, Oxford.*
1872. Apr. 8	Phayre, Major-General Sir Arthur Purves, K.C.S.I., C.B., Governor of the Mauritius. "*Care of Messrs. H. S. King and Co.*, 45 *Pall Mall, London, S.W.*"
1841. Apr. 12	*Phibbs, William, Esq. *Seafield, Sligo.*
1863. Apr. 13	Pigot, David R., Esq., M.A., Master, Court of Exchequer. 12, *Leeson-park, Dublin.*
1870. Apr. 11	Pigot, Thomas F., Esq., C.E., Prof. of Descriptive Geometry, etc., Royal College of Science, Dublin. 4, *Wellington-road, Dublin.*
1838. Feb. 12	*Pim, George, Esq., J.P. *Brennanstown, Cabinteely, Co. Dublin.*
1849. Jan. 8	*Pim, Jonathan, Esq. *Greenbank, Monkstown, Co. Dublin.*
1851. Jan. 13	*Pim, William Harvey, Esq. *Monkstown House, Monkstown, Co. Dublin.*

Date of Election.	
1873. Jan. 13	*Porter, Alexander, Esq., M.D., F.R.C.S., Assist.-Surgeon, Indian Army. *Madras.*
1875. Jan. 11	†Porter, George Hornidge, Esq., M.D., Surgeon in Ordinary to the Queen in Ireland, M. Ch. (Hon. Caus.). 3, *Merrion-square, North, Dublin.*
1852. Apr. 12	*Porter, Henry J. Ker, Esq. *Hanover-square Club, London, W.*
1836. Apr. 25	*Porter, Rev. Thomas Hamblin, D.D. *Ballymully Glebe, Tullyhogue, Dungannon.*
1873. Jan. 13	Powell, George Denniston, Esq., M.D., L.R.C.S.I. 76, *Leeson-street, Upper, Dublin.*
1864. June 13	†Power, Sir Alfred, K.C.B., M.A., Vice-President of the Local Government Board for Ireland. 35, *Raglan-road, Dublin.*
1875. April 12	*†Powerscourt, The Right Hon. Mervyn Wingfield, Lord Viscount. *Powerscourt, Enniskerry, Bray.*
1854. June 9	Pratt, James Butler, Esq., C.E. *Drumsna, Co. Leitrim.*
1874. Dec. 14	*†Purcell, Mathew John, Esq. *(Burton, Co. Cork).*
1858. Jan. 11	Purser, John, jun., Esq., M.A. *Lota, Blackrock, Co. Dublin;* 6, *Mountpleasant, Belfast.*
1867. Jan. 14	*†Read, John M., General, U.S.; Consul-General of the U.S.A. for France and Algeria, Member of American Philos. Soc., Fellow of the Royal Soc. of Northern Antiquaries, &c. *Athens.*
1877. April 9	†Reade, Rev. George H., J.P. *Greythorn, Glenageary, Kingstown.*
1846. Dec. 14	*Reeves, Very Rev. William, D.D., M.B., LL.D., Dean of Armagh. *The Public Library, Armagh; Rectory, Tynan.*
1843. Feb. 13	**Renny*, Henry L., F.R.G.S.I., Lieut. R.E., (Retired List). [*Quebec.?*]
1875. Jan. 11	Reynolds, James Emerson, Esq., M.D., Professor of Chemistry in the University of Dublin. 62, *Morehampton-road, Dublin.*
1867. Apr. 8	Richey, Alexander George, Esq., LL.D., Q.C., a Vice-President of the Academy. 27, *Pembroke-street, Upper, Dublin.*
1875. June 14	Robertson, John C., Esq., L.K.Q.C.P.I., M.R.S.I. *The Asylum, Monaghan.*
1816. Feb. 14	*Robinson, Rev. Thomas Romney, D. D., F. R. S., F.R.Ast.S., Hon.M.I.C.E.Lon., Hon.M.I.C.E.I., Hon. M. Cambridge Phil. Soc., Hon. M. Acad. Palermo, Hon. M. Acad. Philadelphia, Hon. F. R.G.S.I., Royal Medallist, R.S., 1862, Director of

Date of Election.	
1876. Jan. 11	*†Ross, Rev. William. *Chapel Hill House, Rothesay.*
1870. Nov. 30	Rosse, Rt. Hon. Lawrence, Earl of, D.L., D.C.L., V.P.R.S., F.R. Ast. S. *Birr Castle, Parsonstown,*
1872. Apr. 8	†Rowley, Standish G., Esq., J.P., M.R.S.L. *Sylvan Park, Kells, Co. Meath.*
1868. Feb. 10	Russell, Very Rev. Charles William, D.D., President of the Royal College of St. Patrick, Maynooth. *The College, Maynooth.*
1843. Jan. 9	*Salmon, Rev. George, D.D., D.C.L. (Oxon.), LL.D. (Cantab.), F.R.S., and Royal Medallist, 1868, Regius Professor of Divinity in the University of Dublin. 81, *Wellington-road, Dublin.*
1853. Jan. 10	*Sanders, Gilbert, Esq. *Albany Grove, Monkstown, County Dublin.*
1851. May 12	*Sayers, Rev. Johnston Bridges, LL.D. *Velore, Madras.*
1848. Feb. 14	†Segrave, O'Neal, Esq., D.L. *Kiltimon, Newtownmountkennedy.*
1846. Feb. 9	*†Sherrard, James Corry, Esq. 7, *Oxford-square, Hyde-park, London.*
1873. Jan. 13	*†Shirley, Evelyn Philip, Esq., M.A., D.L., F.S.A. *Lough Fea, Carrickmacross; Lower Eatington Park, Stratford-on-Avon.*
1847. Jan. 11	*Sidney, Frederick J., Esq., LL.D., F.R.G.S.I., Secretary of the Royal College of Science, Dublin. 19, *Herbert-street, Dublin.*
1869. Apr. 12	Sigerson, George, Esq., M.D., M.Ch., F.L.S., Prof. of Botany, C.U.I. 3, *Clare-street, Dublin.*
1861. Apr. 8	Sloane, John Swan, Esq., C.E. *Balmoral Lodge, Castle Avenue, Co. Dublin;* 21, *Westmoreland-street, Dublin.*
1835. Feb. 23	*Smith, Aquilla, Esq., M.D., F.K. & Q.C.P.I., King's Prof. of Materia Medica and Pharmacy, Dub. Univ. 121, *Baggot-street, Lower, Dublin.*
1877. Dec. 10	*†Smith, Charles, Esq. *Barrow-in-Furness.*
1868. Jan. 13	†Smith, John Chaloner, Esq., C.E. *Engineer's Office, Dublin, Wicklow and Wexford Railway, Bray.*
1833. Apr. 22	*Smith, Joseph Huband, Esq., M.A.
1876. June 26	Smith, Rev. Richard Travers, (Canon) B.D. *The Vicarage, Clyde-road, Dublin.*
1873. Jan. 13	Smyth, Patrick James, Esq., M.P., Chev. L. H. 15, *Belgrave-square, East, Rathmines, Co. Dublin.*
1867. Jan. 14	Smythe, William Barlow, Esq., M.A., D.L. *Barbaville House, Collinstown, Killucan.*

Date of Election.	
1853. Apr. 11	*Stewart, Henry H., Esq., M.D., F.R.C.S.I. 75, *Eccles-street, Dublin.*
1874. Dec. 14	Stewart, James, Esq., M.A. (Cantab.), Professor of Greek and Latin, C.U.I. 21, *Gardiner's-place, Dublin.*
1871. June 12	Stokes, Whitley, Esq., LL.D., Secretary to the Supreme Council of India. *Legislative Council House, Calcutta.*
1874. June 22	Stokes, William, Esq., M.D., M.Ch. 5, *Merrion-square, North, Dublin.*
1857. June 8	*Stoney, Bindon B., Esq., C.E., F.R.G.S.I. 42, *Wellington-road, Dublin.*
1856. Apr. 14	Stoney, George Johnstone, Esq., M.A., F.R.S., Secretary to the Queen's University in Ireland. *Palmerston-road, Co. Dublin.*
1857. Aug. 24	*Sullivan, William Kirby, Esq., Ph.D., President of Queen's College, Cork. *Queen's College, Cork.*
1874 Apr. 13	†Sweetman, H. S., Esq. 38, *Alexandra-road, St. John's Wood, London, N.W.*
1845. Feb. 24	*Sweetman, Walter, Esq., J.P. 4, *Mountjoy-square, (North), Dublin.*
1871. Jan. 9	†Symons, John, Esq. 72, *Queen-street, Hull.*
1845. June 23	*Talbot de Malahide, Right Hon. James, Baron, D.C.L., D.L., F.R.S., F.S.A., F.G.S., F.R.G.S.I., F.R. Hist. Soc., Pres. Archæol. Inst. *The Castle, Malahide, Co. Dublin.*
1877. April 9	Tarleton, Francis Alexander, LL.D., F.T.C.D. 24, *Leeson-street, Upper, Dublin.*
1848. Feb. 14	*†Tarrant, Charles, Esq., C.E. *Waterford.*
1846. Jan. 12	*Tenison, Colonel Edward King, M.A., Lieutenant of the County Roscommon. *Kilronan Castle, Keadue, Carrick-on-Shannon.*
1866. June 11	†Thom, Alexander, Esq., J.P. *Donnycarney House, Artane, Co. Dublin.*
1869. Apr. 12	Tichborne, Charles Roger C., Esq., F.C.S.L. 23, *Gardiner-street, Middle, Dublin; Apothecaries' Hall,* 40, *Mary-street, Dublin.*
1869. June 14	Tobin, Sir Thomas, F.S.A., D.L. *Ballincollig, Cork.*
1864. Mar. 16	Trench, Right Hon. and Most Rev. Richard-Chenevix, D.D., Lord Archbishop of Dublin, Primate of Ireland. *The Palace, St. Stephen's-green, (North), Dublin.*
1846. Feb. 9	*Tuffnell, Thomas Joliffe, Esq., F.R.C.S.I., M.R.C.S.E.

HONORARY MEMBERS.

Date of Election.	
1863. June 22	HIS ROYAL HIGHNESS ALBERT-EDWARD, PRINCE OF WALES.

"*The* PRESIDENT OF THE ROYAL SOCIETY, AND EX-PRESIDENTS *of the same, are always considered Honorary Members of the Academy.*"—By-Laws, ii., 14.

1869. Mar. 16 (Elected Hon. Mem. in Sec. of Science originally.)	Hooker, Sir Joseph Dalton, M.D., K.C.B., F.R.S., D.C.L., LL.D., V.P.L.S., F.G.S., Director of the Royal Gardens, Kew, PRESIDENT OF THE ROYAL SOCIETY. *Kew, London, W.*
1863. Mar. 16	Sabine, General Sir Edward, R.A., K.C.B., D.C.L., LL.D., V.P. and EX-PRESIDENT OF THE ROYAL SOCIETY, Hon. F.R.S., Edin., F.R.A.S., F.L.S., &c. 13, *Ashley-place, Westminster, London, S.W.*
1832. Nov. 30 (Elected Hon. Mem. in Sec. of Science originally.)	Airy, Sir George Biddell, K.C B., D.C.L., LL.D., EX-PRESIDENT OF THE ROYAL SOCIETY (1871), Astronomer Royal, V.P. R. Ast. S., &c. *The Royal Observatory, Greenwich, London, S.E.*

SECTION OF SCIENCE.

[Limited to 30 Members, of whom one-half at least must be foreigners.]

1873. Mar. 15	Adams, John Couch, LL.D., (Dub.) F.R.S. and Copley Medalist, V.P.R. Ast. S., F.C.P.S., etc., Director of the Observatory and Lowndsean Professor of Astronomy and Geology in the University of Cambridge. *Observatory, Cambridge.*
1874. Mar. 16	Berthelot, Marcelin Pierre Eugène. *Boulevard Saint-Michel,* 57, *Paris.*
1875. Mar. 16	Bertrand, Joseph. *Paris.*
1869. Mar. 16	Bunsen, Robert Wilhelm Eberard, Ph.D., For. Mem. R.S. *Heidelberg.*
1869. Mar. 16	Carus, J. Victor, Professor of Comparative Anatomy. *Leipsic.*
1873. Mar. 15	Cayley, Arthur, LL.D. (Dub.), F.R.S., V.P. R. Ast. S., &c., Sadlerian Professor of Mathematics in the University of Cambridge. *Cambridge.*
1866. Mar. 16	Chasles, Michel, For. Mem. R.S. *Rue du Bac,* 62, *Paris.*

HONORARY MEMBERS—*Continued.*

SECTION OF SCIENCE—Continued.

Date of Election.	
1876. Mar. 16	Borchardt, Carl Wilhelm. *Berlin.*
1873. Mar. 15	Dana, James Dwight, LL.D., &c., Professor of Geology and Mineralogy. *Yale College, U. S., America.*
1866. Mar. 16	Darwin, Charles, F.R.S., &c. *Down, Beckenham, Kent.*
1869. Mar. 16	Daubrée, Prof. Gabriel Auguste. *Ecole des Mines, Paris.*
1876. Mar. 16	Decandolle, Alphonse, For. Mem. R.S., Professor of Botany. *Geneva.*
1863. Mar. 16	Dove, Heinrich Wilhelm, For. Mem. R.S. *Berlin.*
1841. Mar. 16	Dumas, Jean Baptiste, For. Mem. R.S., G.C.L.H., Secretáire perpétuel de l'Institut de France. *Rue St. Dominique*, 69, *Paris.*
1875. Mar. 16	Gray, Asa, Professor of Botany, Harvard University. *Cambridge, Massachusetts, U. S., America.*
1876. Mar. 16	Haeckel, Ernst, Professor of Zoology. *Jena.*
1864. Mar. 16	Helmholtz, Hermann Louis, For. Mem., R.S. *Heidelberg.*
1873. Mar. 15	Hofmann, August. Wilhelm, Professor of Chemistry in the University. *Berlin.*
1874. Mar. 16	Huxley, Thomas Henry, M.D., LL.D., Fellow and Secretary of the Royal Society. *London.*
1864. Mar. 16	Hyrtl, Carl Joseph, For. Mem. R.S *Vienna.*
1874. Mar. 16	Lamont, Johann Von, For. Mem. R.S. *Munich.*
1878. Mar. 16	Pasteur, Louis. *Paris.*
1873. Mar. 15	Schimper, Wilhelm Philipp, Professor of Geology in the University. *Strasburg.*
1869. Mar. 16	Séquard, Charles Edouard Browne-, M.D., F.R.C.P., F.R.S. *Rue Gay-Lussac*, 28, *Paris.*
1873. Mar. 15	Stokes, George Gabriel, D.C.L., LL.D. (Dub.), Fellow and Secretary of the R.S., F.C.P.S., F.R.S.Ed., &c., Lucasian Professor of Mathematics in the University of Cambridge. *Lensfield Cottage, Cambridge.*
1878. Mar. 16	Thomson, Sir William, LL.D., D.C.L. *The College, Glasgow.*
1867. Mar. 16	Würtz, Adolph Charles, For. Mem. R.S. *Rue St. Guillaume*, 27, *Paris.*

SECTION OF POLITE LITERATURE & ANTIQUITIES.

[Limited to 30 Members, of whom one-half at least must be foreigners.]

Elected in the Department of Polite Literature.

Date of Election.	
1869. Mar. 16	Gayangos y Arce, Don Pascual de. *London.*
1869. Mar. 16	Lassen, Christian, Ph.D. *Bonn.*
1849. Nov. 30	Lepsius, Karl Richard. *Berlin.*
1869. Mar. 16	Mommsen, Dr. Theodore. *Berlin.*
1863. Mar. 16	Müller, Professor Max. *Oxford.*

Elected in the Department of Antiquities.

1869. Mar. 16	Benavides, Don Antonio. *Madrid.*
1848. Nov. 30	Botta, Paul Emile. *Paris.*
1867. Mar. 16	De Rossi, Commendatore Giovanni Battista. *Rome.*
1863. Mar. 16	Keller, Ferdinand. *Zurich.*
1869. Mar. 16	*Larcom, Right Hon. Sir Thomas A., Bart., Major-General, K.C.B., F.R.S., &c. *Heathfield, Fareham, Hants.*
1854. Mar. 16	Mauray, Alfred. *Paris.*
1866. Mar. 16	Nillssen, Rev. S. *Copenhagen.*
1841. Mar. 16	Phillipps, (*late* Halliwell,) James Orchard, Esq., F.R.S., F.S.A. Lond. and Edin., &c. *Hollingbury Copse, Brighton.*
1867. Mar. 16	Visconti, Barone Commendatore P. E. *Rome.*
1867. Mar. 16	Worsaae, Prof. Hans Jacob Asmussen. *Copenhagen.*

Elected since the union of the two classes of Honorary Members in this Section.

1878. Mar. 16	Bradshaw, Henry, Fellow, King's College, Cambridge. *Cambridge.*
1876. Mar. 16	Carlyle, Thomas. *Chelsea, London.*
1878. Mar. 16	Curtius, Georg. *Leipsic.*
1875. Mar. 16	Franks, Augustus Wollaston, M.A., F.R.S., F.S.A. 103, *Victoria-street, London, S.W.*
1875. Mar. 16	Hardy, Sir Thomas Duffus, D.C.L., Deputy-Keeper of the Public Records, England. 35, *North-Bank, Regent's-Park, London, N.W.*
1878. Mar. 16	Kern, H. *Leyden.*
1873. Mar. 15	Longfellow, Henry Wadsworth. *Cambridge, Mass., U. S., America.*
1878. Mar. 16	Newton, Charles, F.S.A. *London.*
1873. Mar. 15	Nigra, His Excellency Cavaliere Constantino, Italian Minister to France. *Paris.*
1876. Mar. 16	Stokes, Margaret. *Carrig-Breac, Howth, Co. Dublin.*
1876. Mar. 16	Stubbs, Rev. William, M.A. *Oxford.*

SUMMARY.

Life Members	189
Annual Members	182
	371
Honorary Members (59 + 4)	63
Total, ...	434

Should any errors or omissions be found in this List, which is revised to 1st May, 1878, it is requested that notice thereof may be given to the Secretary of the Academy. He should also be informed of the death of any Member.

As this list will be kept standing in type, it can be readily corrected from time to time.

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(*Continued from page* ii. *of this Cover.*)

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,, Vol. II. ,, complete. [*Title-p. & Index with Pt.* 1, *Vol. III.*]

,, Vol. III. ,, Part 1, August, 1877 ; Part 2, November, 1878.

,, Vol. I. (Polite Literature and Antiquities), pp. 1 to 378.

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